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Prof. Dr. Mustafa ALTINKÖK

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CHAPTER 1

TRAINING LOAD MANAGEMENT AND INJURY PREDICTION WITH WEARABLE TECHNOLOGY: A METHODOLOGICAL REVIEW

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1. Introduction

In team sports, managing training load and assessing injury risk is critically important for optimizing athlete performance and protecting athlete health (Benson et al., 2020). To achieve these goals, wearable technologies such as Global Positioning Systems (GPS) and accelerometers are widely used, especially in elite and professional male athlete populations (Benson et al., 2020; Cummins et al., 2013; Dellaserra et al., 2014). The use of these technologies has become standard practice in sports like soccer, rugby, and Australian football (Benson et al., 2020; Cummins et al., 2013), and accelerometer-based metrics such as "Player Load" have gained wide acceptance (Gómez-Carmona et al., 2020).

However, despite the proliferation of these technologies, there are serious concerns about the methodological and statistical robustness of the collected data (Crang et al., 2020; Scott et al., 2016). The primary challenges facing wearable technology data include reliability issues in GPS measurements (Scott et al., 2016), non-transparent accelerometer validation processes (Gómez-Carmona et al., 2020), inconsistent data cleaning methods, and differing statistical approaches (Ellens et al., 2022). Environmental factors, device placement, and manufacturers' proprietary processing algorithms also frequently compromise data quality (Crang et al., 2020; Theodoropoulos et al., 2020).

These methodological inconsistencies directly prevents the establishment of a clear relationship between training load and injury (Benson et al., 2020). It has been reported in the literature that low-frequency GPS units (1 Hz or 5 Hz) are less reliable during high-intensity or change-of-direction movements (Scott et al., 2016). Data cleaning and processing procedures, especially for acceleration and deceleration data, are often poorly documented or not reported at all (Ellens et al., 2022).

More importantly, issues with the application of popular analytical models like the "Acute: Chronic Workload Ratio" (ACWR) are highlighted (Benson et al., 2020). In the field of injury prediction, the low accuracy and sensitivity of current models is a common problem, leading to inconclusive evidence regarding the value of metrics derived from wearable devices for predicting injury risk (Kupperman & Hertel, 2020).

A lack of standardization and methodological consensus is cited as one of the biggest obstacles to progress in this field (Cummins et al., 2013). Therefore, the purpose of this methodological review is to critically synthesize the primary statistical limitations and methodological challenges in the use of wearable technology data for training load management and injury prediction in team sports. This study will examine in detail the statistical reliability issues in data collection and processing, the methodological limitations of popular load management models, and the challenges in injury prediction models.

2. Methods

This methodological review synthesized findings from academic literature identified through a systematic semantic search conducted by the Elicit search engine. Elicit states that the search was executed across a database of over 138 million academic papers, including content from Semantic Scholar and OpenAlex.

2.1. Search Strategy and Screening

The primary search query was designed to capture the core research question of this review: "What are the primary methodological challenges and statistical limitations of using wearable technology data (GPS, accelerometer) for training load management and injury prediction in team sports?". This query retrieved the 50 most semantically relevant papers for initial screening.

The retrieved papers were then filtered and screened based on a holistic judgment using a comprehensive set of inclusion criteria. To be included, studies had to: (a) focus on team sport athletes; (b) utilize GPS devices, accelerometers, or combined wearable systems; (c) address training load monitoring or injury risk assessment; (d) include a discussion or critique of methodological or statistical approaches; (e) be a peer-reviewed journal publication, including original research, systematic reviews, or meta-analyses; and (f) provide analytical depth beyond purely descriptive reporting.

2.2. Data Extraction and Thematic Synthesis

Following the screening process, a large language model was employed to perform a structured data extraction from the included papers. Data was systematically extracted into predefined categories relevant to this review's objectives. These categories included "Methodological Challenges" (e.g., study design, sample sizes, standardization issues), "Statistical Limitations" (e.g., inappropriate methods, modeling issues, data processing problems), "Technology-Specific Issues" (e.g., GPS accuracy, sampling rates), "Training Load Challenges" (e.g., issues with acute: chronic workload ratio applications), and "Injury Prediction Limitations" (e.g., model accuracy, sensitivity, injury definition consistency). The extracted data was then synthesized into the primary themes presented in this review, allowing for a critical analysis of the current methodological landscape.

While the initial data extraction was performed by the LLM, all extracted data points were cross-verified against the original full-text articles by the authors to ensure accuracy.

3. Analysis of Methodological and Statistical Challenges

In this section, the primary methodological and statistical challenges underlying the use of wearable technology data for training load management and injury prediction will be analyzed based on findings synthesized from a review of filtered publications.

Before beginning the analysis, it is necessary to understand the demographic characteristics of the studies that form the content of this review. As summarized in **Figure 1**, the scope of the included studies is concentrated in specific areas. The vast majority of the reviewed literature focuses on GPS and accelerometer technologies (**Figure 1A**), specific sports such as soccer, rugby, and Australian football (**Figure 1B**), and elite/professional male athlete populations (**Figure 1C**). This demographic concentration, as will be discussed in section 3.5, creates a significant limitation on the generalizability of the findings.

(Figure 1A: Technology Types Used in Included Studies)
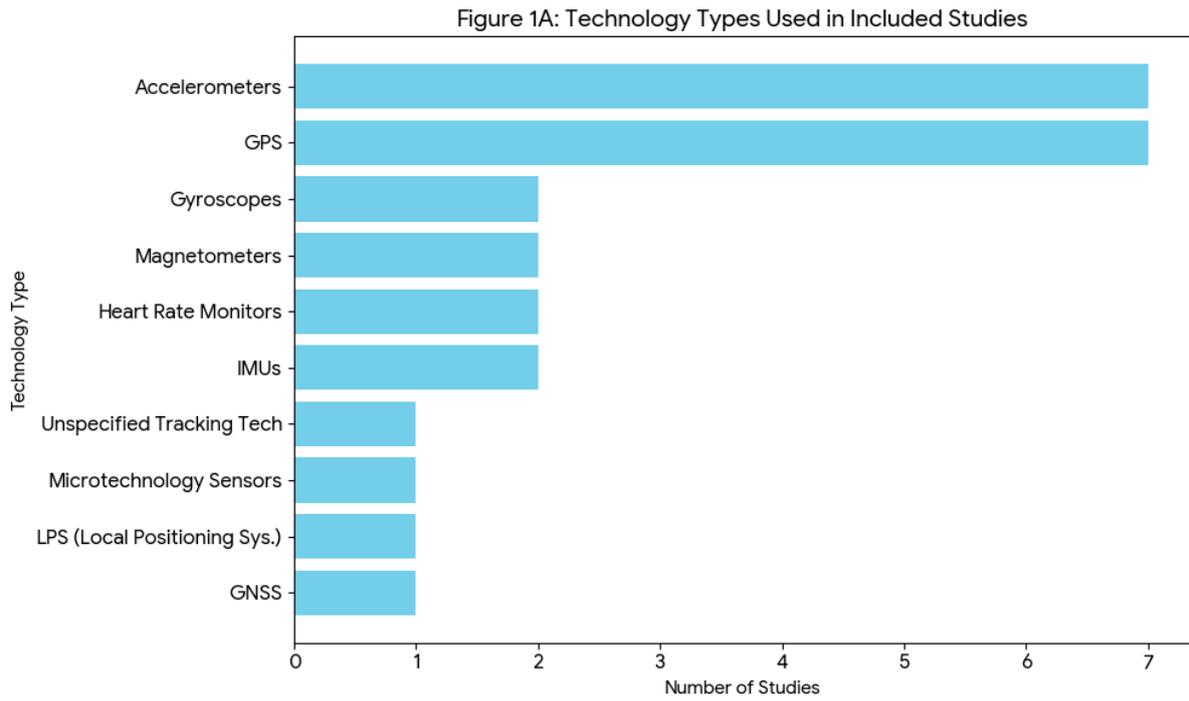
Figure 1A: Technology Types Used in Included Studies

(Figure 1B: Sports Investigated in Included Studies)

Figure 1B: Sports Investigated in Included Studies

(Figure 1C: Population Characteristics in Included Studies)

Figure 1C: Population Characteristics in Included Studies

A horizontal bar chart showing Number of Studies (x-axis, 0 to 5) by Population Characteristic (y-axis):

- No mention found: 5
- Elite/professional: 5
- Male: 4
- Amateur: 2
- University: 1
- Junior: 1
- Youth/academy: 1
- Semiprofessional: 1
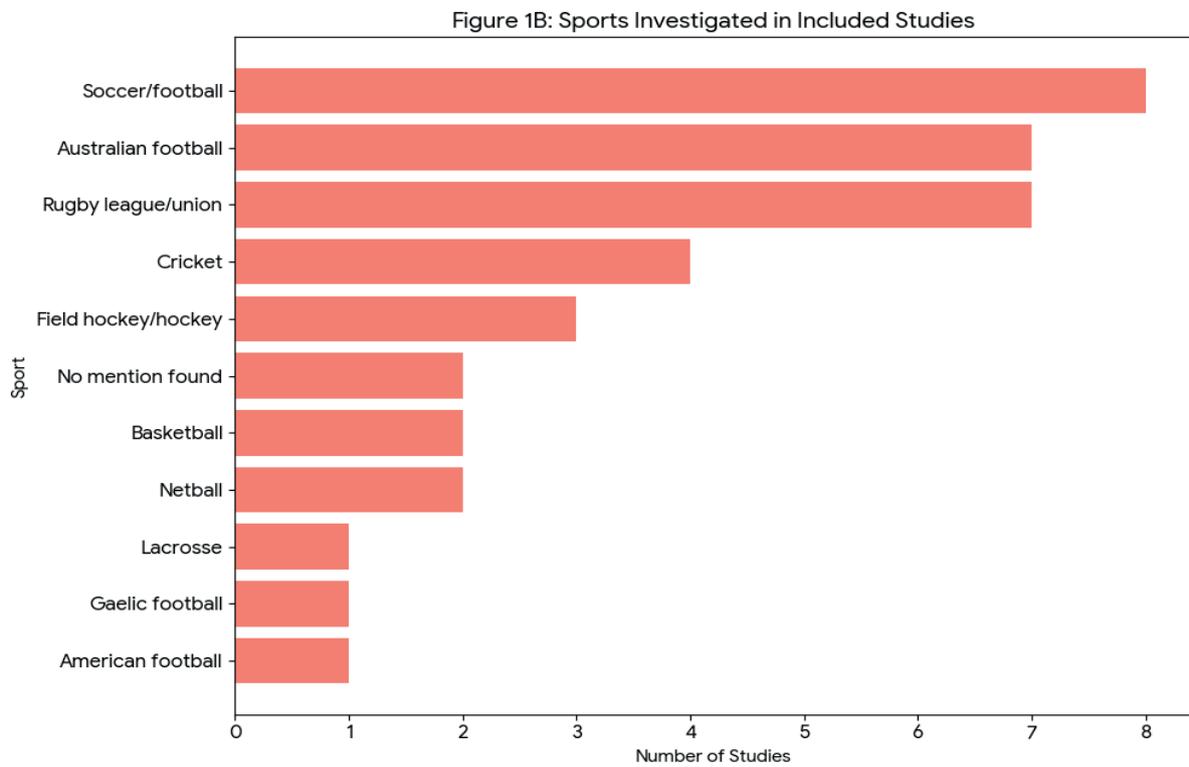
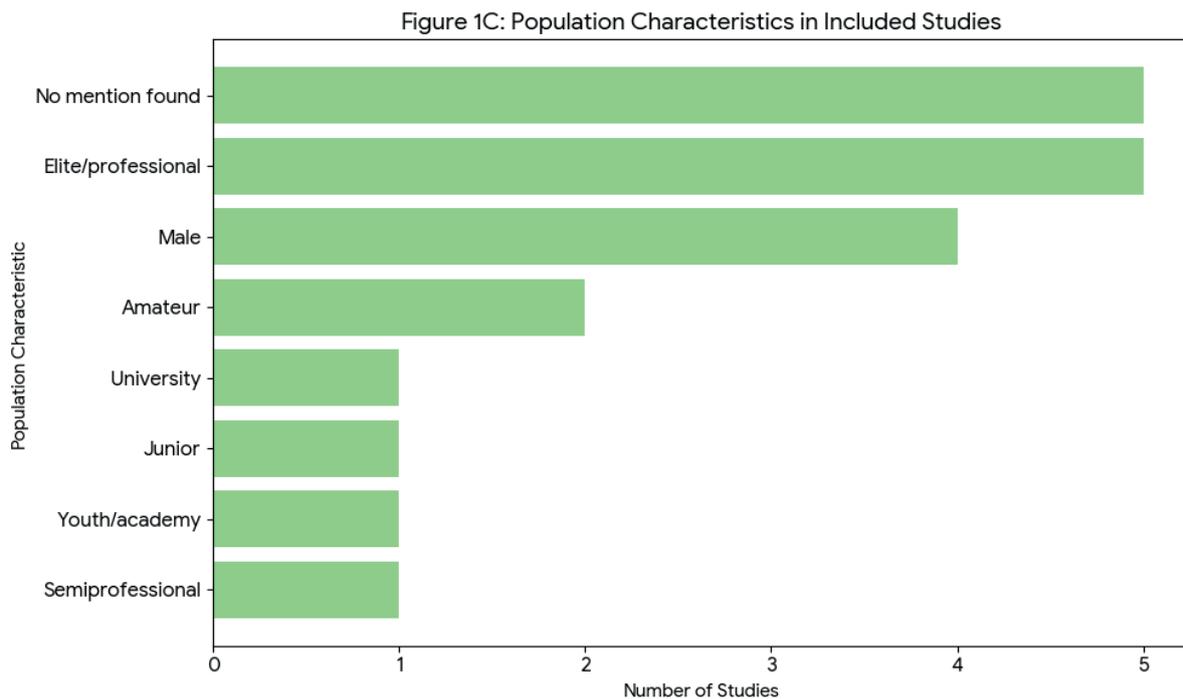**Figure 1.** Characteristics of Included Studies. (A) Technology Types Used in Included Studies. (B) Sports Investigated in Included Studies. (C) Population Characteristics in Included Studies.

This part of the analysis will focus on the qualitative findings derived from these studies. The most fundamental obstacle to translating data from wearable technologies into practical applications is the methodological inconsistencies in the data's validity, reliability, and processing. These challenges will be detailed in the following subsections and in **Table 1**.

3.1. Validity, Reliability, and Data Processing Challenges

The literature reports significant concerns about the accuracy and reliability of wearable technology data. These issues directly affect the quality of the data and, consequently, the results of any statistical analysis based on it.

3.1.1. Device Accuracy and Reliability

Device accuracy is reported to be largely dependent on the sampling rate, the type of movement, and the device brand or model. Low-frequency GPS units (1 Hz or 5 Hz) are noted to be less reliable during high-intensity runs or change-of-direction movements (Scott et al., 2016), whereas 10 Hz devices are stated to offer better, though still not flawless, performance. This situation raises doubts about the accuracy of metrics closely associated with injury risk, such as acceleration and deceleration (Ellens et al., 2022).

3.1.2. Issues with Accelerometer-Based Metrics (Player Load)

In addition to GPS, accelerometer-based metrics like "Player Load" are widely used to measure workload (Gómez-Carmona et al., 2020). However, it is frequently emphasized that these metrics lack a transparent validation process and consistent reliability reporting (Gómez-Carmona et al., 2020). Many studies provide limited reporting on the validity and reliability of these measurements, which weakens the scientific basis of workload management based on these indices.

3.1.3. Environmental and Procedural Factors

The accuracy of both GPS and accelerometer data is affected by environmental factors such as indoor use and satellite availability, as well as by device placement and inconsistent data processing algorithms. The fact that device performance varies from sport to sport (Theodoropoulos et al., 2020) and the proprietary algorithms used by manufacturers (who do not fully disclose how they process data) (Crang et al., 2020) further complicate data comparability between different devices or studies.

3.2. Standardization and Methodological Inconsistencies

In addition to data quality issues, one of the most recurring themes in the literature is the lack of methodological standardization. This situation hinders meaningful comparisons and synthesis between studies.

3.2.1. Lack of Standardized Definitions and Metrics

It is reported that both "training load" and "injury" definitions vary greatly across studies. Basic metrics, such as speed zones and activity descriptors, lack consistency even within the same sport. This lack of definition makes it nearly impossible to aggregate (meta-analyze) or compare results from different studies.

3.2.2. Poor Documentation of Data Processing

Another critical deficiency in research is the lack of transparent reporting on the processes by which data is "cleaned" and "derived." Segmentation algorithms or data cleaning procedures, especially those used for deriving acceleration and deceleration data, are often poorly documented or not specified at all.

3.2.3. Influence of Proprietary Algorithms

A factor that further complicates the situation is the "proprietary algorithms" used by device manufacturers. Each device processing and filtering data in its own unique way makes cross-device comparability between different brands or models (e.g., Catapult vs. STATSports) difficult and complicates data interpretation.

Table 1. Summary of Key Methodological Challenges in the Use of Wearable Technology Data.

Main Theme	Identified Key Challenges
Validity and Reliability Challenges	• Device accuracy depends on sampling rate, movement type, and device. • Low-frequency GPS (1 Hz, 5 Hz) is less reliable in high-intensity movements. • Accelerometer metrics (e.g., PlayerLoad) lack transparent validation and reliability reporting. • Environmental factors (indoor use, satellite access), device placement, and inconsistent data processing algorithms affect accuracy.
Standardization and Methodological Inconsistencies	• Lack of standardization in key definitions (e.g., workload metrics, speed zones, injury definitions). • Hindrance of cross-study comparisons and synthesis. • Data derivation and cleaning procedures (esp. for acceleration/deceleration) are often poorly documented or omitted. • Manufacturers' proprietary algorithms complicate cross-device comparability. • Lack of consensus guidelines impeding progress in the field.

3.3. Application-Specific Challenges: Training Load Management

The ultimate goal of data from wearable technologies is to optimize training programs and make athletes more resilient. However, current evidence shows significant obstacles to the data serving this purpose.

3.3.1. Methodological Issues with the Acute: Chronic Workload Ratio (ACWR)

It is frequently highlighted that there are methodological issues with the Acute: Chronic Workload Ratio (ACWR), one of the most commonly used models in training load management literature. The statistical foundations of this model (based on the ratio of an athlete's recent load to their longer-term chronic load) and its true reliability in determining injury risk are subjects of ongoing debate in the literature.

3.3.2. The Gap Between Data Collection and Actionable Coaching Decisions

Research reveals a significant gap between data collection and its practical application on the field. Many studies report that coaches and practitioners struggle to translate this complex, multidimensional data into actionable and individualized coaching decisions. A lack of data literacy is cited as one of the key factors preventing the conversion of this data into actionable insights. Additionally, the difficulty in establishing a clear "dose-response" relationship between training load and injury or performance has also been reported. These uncertainties limit the practical value of the collected data and pose an obstacle to effective training load management.

3.4. Application-Specific Challenges: Injury Prediction Models

One of the most promising areas for wearable technologies is the proactive prediction of athlete injuries. However, the literature synthesized by the Elicit report shows that there are serious statistical and methodological obstacles to achieving this goal.

3.4.1. Low Model Accuracy and Sensitivity

One of the most frequently reported problems with injury prediction models is their low accuracy and, especially, sensitivity. Since injuries are statistically "rare events," models often appear successful at predicting that an injury will not occur, but fail to catch an impending injury (a true positive). This situation leads to models having high "false positive" (false alarm) or "false negative" (missed) rates, severely limiting their practical utility.

3.4.2. Inconsistent Injury Definitions and Temporal Relationships

Another fundamental problem in the literature is the inconsistency of the "injury" definition across studies. An injury defined in one study as "causing missed training" may be defined in another as "requiring medical intervention." This inconsistency makes it impossible to combine the results of different studies. Furthermore, it is noted that establishing a clear temporal

relationship between an increased training load and the occurrence of an injury is difficult.

3.4.3. Failure to Account for Non-Load Risk Factors

Most current models overlook the multifactorial nature of injury by focusing solely on training load metrics. Non-load risk factors that affect injury risk, such as an athlete's previous injury history, psychological state, sleep quality, or biomechanical characteristics, are often excluded from the models. This limits the models' capacity to capture real-world injury complexity. Consequently, due to methodological heterogeneity and a lack of robust statistical modeling, most studies remain "inconclusive" regarding the value of metrics derived from wearable devices for predicting injury risk.

3.5. Limitations of the Current Evidence Base

The evidence base provided by research on wearable technologies contains significant demographic and sampling limitations, in addition to methodological problems. This situation seriously affects the generalizability of current findings.

3.5.1. Narrow Focus on Elite, Male Athlete Populations

The vast majority of the current literature focuses on elite or professional-level male athletes. Specific sports such as soccer, rugby, and Australian football are overrepresented in research. This narrow focus limits the generalizability of the findings.

3.5.2. Unrepresentative Samples and Excluded Groups

The sample sizes used in studies are often small and far from representative of broader populations. There is a noticeable lack of research on female athletes, youth athletes, and less-resourced sports. This situation leads to a skewed evidence base and prevents reaching valid conclusions for these groups.

3.5.3. Reliance on Secondary Data and Reporting Limitations

It is noted that many of the reviewed meta-analyses rely on secondary data or abstracts only, which restricts the depth of the methodological critique. Furthermore, studies based on practitioner surveys are subject to inherent limitations such as response and selection bias.

4. Discussion and Future Directions

The findings presented in this review clearly show that the current use of wearable technologies in team sports falls short of its ambitious goals (such as injury prediction). The methodological and statistical limitations in data collection, standardization, analytical models (like ACWR), and injury prediction are the primary obstacles to progress in this field. In this section, these key obstacles will be summarized, and solutions proposed in the literature will be presented as future directions for both researchers and practitioners.

4.1. Summary of Key Methodological Hurdles

Our analysis shows that the fundamental problem is not "too much data," but "a lack of reliable data" and "an absence of standard analysis." Basic issues such as the reliability problems of low-frequency devices, the lack of transparency in proprietary algorithms, and the insufficient documentation of acceleration data make the quality of the collected raw data questionable from

the very beginning. When methodological issues in popular models like ACWR and inconsistent workload and injury definitions are added to this, extracting meaningful results from the data becomes difficult. The failure of injury prediction models to statistically capture "rare events" and the excessive focus on elite male populations also limit the generalizability of the current evidence base.

Distinct from previous reviews (Benson et al., 2020; Cummins et al., 2013) that have broadly scoped the general applications and utility of wearable technology in team sports, this study uniquely prioritizes the statistical and methodological underpinnings of these tools. While earlier research has largely focused on 'what' these technologies can monitor, our review critically examines 'how' the data is derived and validated. By specifically isolating the inconsistencies in data processing protocols, proprietary algorithms, and injury prediction modeling, this work diverges from the existing literature to highlight the foundational statistical fragilities that currently limit the clinical translation of wearable data.

4.2. Recommendations for Researchers and Future Directions

To overcome the current limitations, a series of methodological improvements for researchers are proposed in the literature:

- **Standardization and Consensus:** The most urgent need for progress in the field is to develop a consensus on workload and injury definitions, data processing protocols, and reporting standards.
- **Technological Improvements:** Research must prioritize the use of higher-frequency (10 Hz or higher) devices and validated algorithms.
- **Robust Statistical Methods:** The adoption of more robust statistical methods and "gold-standard" validation approaches is critically important.
- **Increasing Representation:** Future research should be expanded to include underrepresented populations such as female athletes, youth, and other populations, as well as less-resourced sports.
-

4.3. Recommendations for Practitioners

As researchers improve methodology, there are also practical recommendations for practitioners in the field:

- **Education and Data Literacy:** Increasing the education and data literacy of practitioners is a fundamental requirement for understanding and correctly interpreting the collected data.
- **From Data to Action:** Future efforts must focus not only on data collection but also on how this data can be translated into individualized and actionable interventions. Given that coaches struggle to convert complex data into practical decisions, establishing this "data-to-action" bridge is of vital importance.

5. Conclusion

This methodological review has comprehensively analyzed the existing scientific infrastructure, statistical reliability, and application challenges of wearable technologies (GPS, accelerometers, and microsensors) used for training load management and injury prediction in team sports. The findings indicate that while wearable technologies offer revolutionary potential for data collection in sports science, significant methodological inconsistencies exist in the processing, interpretation, and translation of collected data into action.

The primary conclusion drawn from the analyzed literature is the existence of a distinct gap between the technology's promised capacity for "proactive injury prediction" and the current methodological reality. This gap is fundamentally driven by three main factors:

First is the issue of technical limitations and lack of transparency in data collection tools. It has been determined that GPS units with low sampling rates (1 Hz - 5 Hz) are insufficient for measuring high-intensity actions, sudden changes of direction, and accelerations inherent in the nature of team sports. Furthermore, "proprietary algorithms" used by commercial manufacturers, which remain closed to the research community, prevent data comparability between devices and render scientific replication impossible.

Second is the lack of standardization in statistical modeling and definitions. There is no universal consensus in the literature regarding the concepts of "training load" and "injury." This lack of consensus prevents the aggregation of results across different studies (i.e., meta-analysis) and the formation of cumulative knowledge. Additionally, mathematical and conceptual flaws in widely used models, such as the Acute: Chronic Workload Ratio (ACWR), undermine the reliability of these metrics in determining injury risk. It is concluded that injury prediction models exhibit low sensitivity and high false alarm rates in predicting injuries, which are statistically characterized as "rare events."

Third is the demographic representation issue within the existing evidence base. The vast majority of examined studies focus on elite-level male players in soccer, rugby, and Australian football. Female athletes, youth development leagues, and amateur populations are underrepresented in the literature, which severely limits the generalizability of the findings.

From a future perspective, to ensure scientific progress in this field, the priority for researchers and practitioners must shift from merely collecting "more data" to generating "higher quality and meaningful data." In this context, the following steps are essential:

1. **Standardization:** Establishing international consensus protocols for data cleaning, processing, and reporting.
2. **Advanced Statistical Methods:** Adopting non-linear machine learning techniques and robust statistical models that encompass the multifactorial nature of injury.
3. **Data Literacy:** Increasing data literacy training for field practitioners (coaches and strength & conditioning specialists) to enable the integration of complex data into decision-making processes.

In summary, wearable technologies will continue to be an indispensable tool for athlete health and performance; however, unlocking their full potential depends not on the technology itself, but on increasing methodological rigor and statistical robustness.

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CHAPTER 2

FROM THE FIELD TO THE MIND: A SYSTEMATIC REVIEW OF THE PERFORMANCE-ENHANCING ROLE OF IMAGERY IN SPORT

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Introduction

Visualization, frequently used in sports psychology, is an effective psychological technique employed by many athletes during training, competitions, and non-training situations, and is also preferred by coaches and other professionals. Visualization stands out as an important skill that enhances success in sports. At the heart of this method lies the creation of mental images and the realization of these images through a design process. Athletes who want to improve their physical and psychological abilities benefit from visualization exercises. Common uses of visualization include increasing self-confidence, strengthening concentration, controlling emotional responses, understanding and developing athletic abilities and strategies, exhibiting a stance against pain and injuries, and overcoming the problems they cause (Taylor and Wilson, 2005; Bayköse, 2014)

Visualization and Sport

Visualization techniques are frequently used to learn a skill or improve performance. Therefore, athletes can accurately mentally visualize the sport they wish to learn and repeat this process many times. Visualizing the movement fluently and flawlessly in the mind provides an easier experience during the application phase. Accurate mental visualization of the movement will ensure better execution of that movement when it comes to practice. Furthermore, visualization techniques contribute to the performance of athletes by increasing their concentration during movement. Visualization can be easily applied by individuals at every level in the sports environment. No matter how complex the skill to be performed by the athlete, visualization exercises for that skill are vitally important (Tiryaki, 2000; Karagözoğlu, 2005; Weinberger and Gould, 2015).

Imagery Models Used in Sports

As a result of research, various imagery models used in the field of sports have been developed. These models are:

• "Pettlep Model"

• The Four "N"s of Imagery in Sports (Imagery Content Model)

• Applied Model of Imagery Use in Sports

• Imagery Ability Model in Sports

• Three-Level Model of Imagery in Sports" (Vurgun, 2010).

Pettlep Model

The Pettlep model was developed by Holmes and Collins in 2001. This model consists of seven basic elements related to motor imagery. The name of the model is derived from the first letters of these elements. Below are the elements and their descriptions (Holmes and Collins, 2002, pp. 98-117):

Physical: Reflects the physical and physiological state of the person involved in the imagery process.

Environment: Used to express the skill level and perspective of the practitioner, in a way that is appropriate to the nature of the skill in which the imagery activity is performed.

Task: Tasks that are appropriate to the practitioner's ability and perspective, based on the structure of the skill in which imagery is used.

Timing: Indicates that the duration of the imagery should be equal to the duration of the physical application of the skill.

Where: Where is imagery used? Especially in the context of training and performance applications, we observe that athletes resort to imagery techniques in different environments such as "on the field, in the locker room, during competition, in camp". Recent studies have shown that athletes use imagery more frequently and regularly in competition areas than in training areas (Munroe et al., 2000). When: Imagery is an important technique used in specific time periods in the field of sports. For example, there are processes where the athlete resorts to imagery before, during or after competitions, before and during training. This technique is an important component and programming element in physical work performed in open or closed areas, as well as in applications during the athlete's rehabilitation period (Munroe et al., 2000).

Why: Regarding why imagery is used, this technique provides benefits in many areas. For example, it plays an important role in skill learning, goal-oriented work, reducing anxiety and stress, and improving performance. Imagery applications also identify existing functional elements and the rationale behind them (Munroe et al., 2000). What: What do you image? The answer to this question may consist of factors such as the competition situation, various skills, the field, in-game tactics, and spectators. Munroe et al. (2000) stated that the structure of the content and quality regarding the use of imagery in sports provides an answer to the question "what do you image?". According to this perspective, the content structure, consisting of six factors, appears as elements related to the imagery section, activity, environment, controllability, imagery type, and nature. The subcategories refer to elements related to the quality and process of imagination, including aspects such as perspective, affective involvement, image manipulation, and generation (Munroe et al., 2000).

An Applied Model of the Use of Imagery in Sports

Martin et al. (1999) categorized the use of imagery around five basic points:

a) Cognitive General (CG): Imagery of strategies related to competitions; for example, mentally visualizing tactics such as one-on-one defense, front-shot, and dribble.

b) Cognitive Specific (CS): Imagery related to skill development and creation; such as mentally visualizing running technique, penalty shots in hockey, or a successful serve in tennis.

c) Motivational General Arousal (MG-A): Imagery related to relaxation, competition, or excitement in connection with bodily and emotional experiences; for example, mentally visualizing feelings such as arousal, excitement, anxiety, and stress.

d) Motivational General Mastery (MG-M): Imagery representing effectively coping with difficult situations and the individual's self-confidence; for example, remaining calm despite mistakes, focusing on the activity, and exhibiting a positive attitude. e) Motivational Specific (MS): Imagery practices that describe behaviors performed in line with specific goals; the effort to achieve personal aims, the mental visualization of goals such as winning a competition or receiving a medal (Martin et al., 1999).

The Model of Imagery Ability in Sport

This model, developed by Watt and Morris (2001), consists of three phases: single sense, image formation, and feeling. The characteristics of the third phase include the combination of visual sensory methods with the components of vividness, control, duration, ease, and speed. Two latent factors in the model encompass the tactile, kinesthetic, and emotional sub-dimensions of imagery ability in sport; while the auditory, olfactory, and gustatory sub-dimensions shape the rest of the model. The second latent factor reveals the relationship of these characteristics to common bodily sensations; while the third latent factor refers to non-visual sensations not related to somatic (physical) sensory organs (Morris et al., 2006, pp. 148-173).

Three-Level Model of Imagery in Sports

Imagery in sports is addressed using a three-level model developed by Murphy and Martin (2002). This model explains the different levels of imagery and is detailed as follows:

1. Level: The nature of imagery; this stage explains the general structure of the cognitive and psychological processes used together, taking into account the existing characteristics of the structure of imagery.

2. Level: Goal-oriented imagery use; this level examines how athletes generally use imagery and the effect of mental preparation applied through imagery on performance. The aim here is for the individual to visualize themselves achieving their goals by making mental visualizations.

3. Level: The meaning of the image (for the athlete); Murphy and Martin, referring to Ahsen's (1984) work, further expanded the role of imagery in sports. The meaning of the image for an athlete is quite important and this meaning can vary from person to person. For example, an image that is a source of stress and anxiety for one athlete may create a sense of confidence for another (Murphy and Martin, 2002, pp. 405–439).

METHOD

Research Model

This study was conducted using a systematic review method to present the results of studies on imagery in sports conducted between 2010 and 2025. Systematic review involves evaluating research quality by reviewing studies in the relevant field to find an answer to a specific research question or to develop a solution to a problem, determining the parameters for which studies will be used, and evaluating the obtained data together. Limitations of the Research

One limitation of this research is that only publicly accessible sources were evaluated.

Data Collection Tools

While examining studies conducted in the field of imagery in sports, Google Scholar, Dergipark, and YÖK-TEZ databases were used. During the research, a total of 13 different studies suitable for the purpose of the research were obtained using 3 different keywords under the headings of "Imagery", "Sport", and "Training", and these studies were included in the review.

FINDINGS

The results of the data included in the research are evaluated and presented in Table 1 below.

Table 1. Information about studies on imagery.

(Uyaroğlu, 2024)	This study aimed to investigate the effects of imagery training on the non-dominant leg of young male soccer players on dribbling, ball control, and passing/shooting techniques in soccer, using bilateral transfer to examine leg asymmetry.	A total of 36 volunteer participants aged 14-15 years (born in 2009-2010) were divided into three groups. The first group consisted of participants who performed imagery and non-dominant leg training (n=12), the second group consisted of participants who performed video imagery and non-dominant leg training (n=12), and the third group was the control group (n=12). The first and second groups received 20 minutes of imagery training and 20 minutes of non-dominant leg training twice a week for four weeks, with at least one day off. Participants in the control group continued their daily training, which included warm-up, main training, and cool-down phases.	In conclusion, research conducted on young football players shows that imagery exercises performed before non-dominant leg training significantly contribute to the development of dribbling, passing, and shooting skills with the dominant leg. Furthermore, the use of video imagery techniques has been shown to have an even more pronounced impact on the football skills of young players.
(Çamlıbel, 2024)	The aim of this study is to examine the effects of a 12-week visualization training program on various performance parameters in U12 tennis players.	Tennis players (n=24) participating in the study were randomly divided into two groups. The control group (n=12) received traditional tennis training, while the experimental group received both tennis training and imagery training. Imagery training was conducted using the PETTLEP model from weeks 1-6, and from weeks 7-12, using virtual reality glasses, basic tennis technique videos, match clips, and techniques of famous players. Measurements were administered twice to the participants, both as a pre-test and a post-test.	In this context, it was concluded that the visualization training conducted could significantly improve the visualization level of tennis players.
	The aim of this study is to investigate how imagery training	The study included a total of 68 kickboxing athletes aged 12-16 who trained regularly three	The results showed that the visualization exercise, added to the

(Kaygusuz, 2023)	affects the proprioception of kickboxing athletes.	days a week. 40 of these athletes were male and 28 were female. The study group consisted of 20 males and 16 females who underwent a 15-minute visualization exercise before each kickboxing training session for eight weeks. The control group only performed kickboxing training during this period and did not participate in the visualization exercises.	training program, improved the athletes' proprioception.
(Boz, 2023)	The main objective of this research is to examine the effects of imagery exercises on target punching, motor imagery skills, and proprioceptive senses of karate practitioners. To this end, the study was conducted with 31 karate athletes aged 15-17. could be effective in improving target punching, motor imagery skills, and proprioceptive senses of karate athletes.	The research group was divided into two groups: an experimental group and a control group. The experimental group underwent motor imagery exercises for 8 weeks, while the control group only performed karate training and did not participate in imagery exercises. Measurements were taken at four different times during this period. Three separate measurements were used to evaluate the parameters: target punching performance, repositioning test, and motion imagery scale. In conclusion, it was stated that the motor imagery exercises conducted could be effective in improving target punching, motor imagery skills, and proprioceptive senses of karate athletes.	In conclusion, it has been stated that the motor imagery exercises conducted can be effective in improving the target-oriented punches, motor imagery skills, and proprioceptive senses of karate athletes.
(Karakoç, 2023)	The aim of this study is to examine the effect of mental training on the shooting scores and mental endurance levels of archery athletes aged 15-21. The research aims to improve the shooting performance of archery athletes, increase their attention levels, and	This study was conducted with licensed athletes from the Istanbul Beyoğlu Archery Foundation Sports Club. Before and after the study, the scores obtained by the control and experimental groups in the Turkish Ranking Score 1 and Turkish Ranking Score 2 competitions were recorded, and both groups were administered the Mental Endurance Inventory test. The control group continued only	In light of this data, a significant increase in shooting performance and mental resilience was observed in the group that underwent mental training. On the other hand, shooting performance and mental resilience did not change in the group that did not

reduce their anxiety levels.	with physical training for 10 weeks. The experimental group, while continuing with physical training, followed a 40-minute mental training program divided into two parts (20 minutes per session) for 10 weeks.	undergo mental training. In conclusion, the importance and necessity of implementing mental training have been demonstrated.
(Metan, 2022)	The aim of this study is to examine the effects of a psychological skills training (PST) program and positive feedback on self-efficacy beliefs and accurate shooting performance in handball players.	This study involved a 10-week psychological skills training program for handball players. A total of 38 female handball players aged 15-19 participated, divided into two experimental and one control group. The first experimental group received PBA (Psychological Behavioral Therapy), while the second experimental group received both PBA and planned positive feedback.	This study revealed that the PBA program improved athletes' self-efficacy beliefs and shooting accuracy skills. Furthermore, it was determined that the positive feedback provided through PBA further enhanced this effect.
(Kulak, 2020)	The aim of this study is to examine the effect of 10 weeks of mental training involving imagery and internal monologue methods on shooting performance in amateur football players.	The study sample consisted of 30 male athletes aged 14-15 years, all members of the Şanlıurfa GSİM Football Team. The footballers were divided into two groups, a control group and an experimental group, using purposive sampling. Both groups underwent pre- and post-tests before and after 10 weeks of mental training, using the shooting test developed by Kayarlar et al. (1991) to assess height, body weight, and technical skills.	In conclusion, it was determined that the 10-week mental training method improved the technical skill performance of the football players.
(Bakioğlu ve	The aim of this study is to examine the effect of imagery application on standing long jump technique.	The study included 14 female volleyball players with an average age of 20.71 ± 1.06 years. A pre-test was conducted on the subjects using horizontal jump measurements before the imagery application. Following the pre-test, the subjects participated in video-assisted mental training involving correct posture and long jump technique, three days a week	According to the research findings, video-assisted imagery exercises, in addition to physical training, were found to be effective in improving standing long jump technique in volleyball players.

Kandemir, 2020)		for three weeks, in addition to their physical training. At the end of the three weeks, a second horizontal jump test was administered to the subjects who came to the gym. After the second test, for another three weeks, the athletes underwent mental training by watching videos containing incorrect techniques during their physical training.	
(Uludağ, Dorak, Vurgun, 2016)	The main objective of this study was to examine the effects of 10 weeks of visualization and concentration training on eye fixation duration and focal region, which are determinants of visual focus control in dart throwing.	The sample consisted of 23 male athletes studying at Ege University in Izmir, with at least 4 years of sports experience. The average age of these individuals was 23.34 ± 2.7. Before the start of the study, participants were ranked according to a competition method and divided into groups according to their success levels to ensure a homogeneous distribution. The resulting groups were determined as concentration (n=7), visualization (n=8), and control (n=8) groups. Athletes in the visualization group performed internal visualization training, while athletes in the concentration group continued their training with yantra. The effects of visualization and concentration training on focal regions and eye fixation duration were investigated using the ASL eye-tracking module.	As a result, it was observed that the increase in eye fixation duration in the group performing visualization training showed a parallel relationship with the deterioration in the focal region.
(Aldemir, Biçer,	The aim of this study is to examine the effect of imagery exercises on problem-solving skills in enhancing the success of elite athletes. group and 100 in the control group.	The research group consisted of 200 volunteer male athletes aged 16-20 years, actively playing licensed football for at least 3 years at Istanbul Beylerbeyi SK; 100 individuals were in the study group and 100 in the control group. The study group underwent an imagery training program for 30	Based on the findings, it was determined that imagery applications had a positive effect on the problem-solving skills of the football players.

Kale, 2014)		minutes a day, 3 days a week, for 20 weeks. No intervention was applied to the control group. The Problem Solving Inventory (PSI) was administered to both groups at the beginning and end of the study.	
(Aldemir, Biçer, Kale, 2011)	The aim of this study is to examine the effects of visualization exercises on the self-perception of elite football players.	The research group consisted of 200 volunteer male athletes aged 16-20, actively licensed football players with at least 3 years of sports experience at Istanbul Beylerbeyi SK. This group was divided into two groups: 100 in the study group and 100 in the control group. The study group underwent visualization exercises for 30 minutes a day, 3 days a week, for 20 weeks, while the control group received no intervention.	Based on the data obtained, it can be said that visualization exercises had positive effects on the self-perception of the athletes.
(Özdal, Akcan, Abakay, Dağlıoğlu, 2013)	The aim of this study is to examine the effects of video-assisted mental training on football shooting skills.	Thirty athletes aged 13-14 years participated in the study. Participants were divided into three groups: physical training group (FG, n:10), mental training group (ZG, n:10), and a combination of both physical and mental training groups (FZG, n:10). Subjects participated in various training sessions three days a week for four weeks. FG participated only in physical football training; ZG participated only in the video-assisted mental training program; and FZG participated in mental training programs before each physical training session. The Mor-Christian Shooting Ability Test Station was used for the Shooting Ability Test, and measurements were taken twice, on the first day (T1) and the last day (T2) of the training period. It can be said that video-assisted mental training has positive effects on shooting	It can be said that video-assisted mental training has positive effects on shooting skills in football. Furthermore, it is stated that the combined application of both physical and mental training yields more effective results than either physical or mental training alone. Therefore, it is recommended that mental training be integrated with physical training periods in the annual training plan.

		skills in football. Furthermore, it is stated that the combined application of both physical and mental training yields more effective results than either physical or mental training alone. Therefore, it is recommended that mental training be integrated with physical training periods in the annual training plan.	

Uyaroğlu (2024) investigated the effects of imagery exercises performed before non-dominant leg training on leg asymmetry in football through bilateral transfer of dribbling, ball juggling, and passing/shooting techniques. The study included 36 volunteer participants aged 14-15, who were divided into three groups. The first group received imagery training, the second group received video-assisted imagery training, twice a week for four weeks. The third group continued only with their routine training. As a result, it was determined that imagery exercises significantly contributed to dribbling, passing, and shooting skills; furthermore, it was emphasized that video-assisted imagery exercises had a greater impact on football skills.

Çamlıbel (2024) investigated the effects of 12 weeks of imagery training on some performance parameters in U12 tennis players. The study included a total of 24 athletes: an experimental group of 12 tennis players and a control group of 12 tennis players. The experimental group received imagery training based on the PETTLEP model for the first 6 weeks, and from weeks 7-12, they watched basic technical videos, match clips, and footage of famous players applying their techniques using virtual reality glasses. The control group received only traditional tennis training. The results show that imagery training significantly improved the performance parameters of the tennis players in the experimental group.

Kaygusuz (2023) aimed to examine the effects of imagery training on the proprioception sense of kickboxing athletes. The study included a total of 68 kickboxing athletes, 40 male and 28 female, aged 12-16, who trained 3 days a week. The experimental group, consisting of 20 male and 16 female athletes, underwent a 15-minute imagery exercise before training. The control group did not undergo imagery training during this period and only performed kickboxing training. The results showed that imagery training improved the athletes' proprioception sense.

Boz (2023) examined the effects of imagery applications on target punches, motor imagery skills, and proprioceptive senses in karate practitioners. The study included 31 karate athletes aged 15-17. The research was divided into two groups: an experimental group and a control group. The experimental group underwent motor imagery training for 8 weeks. The control group only performed karate training and did not benefit from imagery training. The results showed that motor imagery exercises could improve karate practitioners' target-oriented punches, motor imagery skills, and proprioceptive senses.

Karakoç (2023) investigated the effects of mental training on shooting performance in archery athletes aged 15-21. Athletes from the Istanbul Beyoğlu Archery Foundation Sports Club participated in the study. The athletes were divided into two groups: a control group and an experimental group. The experimental group underwent a mental training program for 10 weeks, and a significant increase in shooting performance was observed in this group. Metan (2022) investigated the effects of a psychological skills training (PST) program on accurate shooting in handball athletes. A total of 38 female handball players aged 15-19 participated in the study. These athletes received psychological skills training for 10 weeks, and it was determined that the training increased their shooting accuracy. Kulak (2020) investigated the effects of internal speech and imagery techniques on shooting performance in amateur football players. The study was conducted on the Şanlıurfa Gençlik Spor amateur football team, consisting of 30 male athletes aged 14-15. Following a 10-week mental training program, it was determined that these methods significantly improved the athletes' shooting skills. Bakioğlu and Kandemir (2020) investigated the effects of imagery training on standing long jump technique. Fourteen female volleyball players participated in the study and benefited from video-assisted mental training for three weeks. At the end of the study, it was determined that video-assisted imagery training played a significant role in the development of the athletes' standing long jump techniques.

Uludağ et al. (2016) examined the effects of imagery and concentration exercises on eye fixation duration and focus area in dart throwing. The study included 23 male athletes studying at Ege University in İzmir with at least four years of sports experience. The subjects were divided into three separate groups: a control group, an imagery group, and a concentration group. As a result of the training, it was determined that the increase in eye fixation duration in the group performing imagery exercises was directly proportional to the impairment in the focus area. Aldemir et al. (2014) investigated the effect of imagery exercises on problem-solving ability in football players to improve their performance. A total of 200 volunteer male athletes aged 16-20 participated in the study; Of these, 100 formed the control group and 100 formed the study group. The control group received no intervention, while the imagery training program was applied only to the study group. An inventory was used to evaluate the problem-solving skills of athletes before and after the research. The findings revealed that imagery training was effective in improving performance.

Aldemir et al. (2014) examined the effects of imagery on self-perception through an imagery study conducted on elite football players. A total of 200 volunteer male athletes aged 16-20 participated in the study. The participants were divided into two groups: a control group of 100 and a study group of 100. While no training was applied to the control group, the study group underwent 20 weeks of imagery training. The findings show that imagery training positively affects the self-perception of the athletes.

Özdal et al. (2013) investigated the effects of video-assisted mental training on shooting skills in football. Thirty athletes aged 13-14 participated in the study. The athletes were divided into three separate groups: a physical training group, a mental training group, and a physical-mental training group. Four-week specialized training programs were implemented for each group. The results show that the mental training had a positive effect on shooting skills in football.

Furthermore, it was determined that the physical-mental training application was more effective than those who only did physical or mental training.

RESULTS and DISCUSSION

This study aimed to reveal the effects of imagery applications on sports performance and psychological variables by systematically reviewing research conducted in the field of imagery in sports between 2010 and 2025. A total of 13 studies obtained from Google Scholar, DergiPark, and YÖK-TEZ databases, covering different age groups and sports branches, were evaluated. The findings of the studies reviewed in this compilation show that visualization exercises have significant and positive effects on both physical performance indicators (shooting, passing, accuracy, motor skills, proprioception) and psychological variables (self-confidence, self-perception, mental resilience, problem-solving skills, concentration). Studies conducted in various sports, particularly football, tennis, karate, kickboxing, archery, handball, and volleyball, strongly support the idea that visualization is a performance-enhancing mental training method.

Research results show that imagery is more effective when used alone, in conjunction with physical training, and within the framework of structured models (PETTLEP, video-assisted imagery, virtual reality applications). It is noteworthy that video-assisted and virtual reality-based imagery studies accelerate athletes' motor learning processes and strengthen skill transfer. Furthermore, imagery has been shown to make significant contributions in areas such as non-dominant side development, bilateral transfer, and proprioceptive awareness. From a psychological perspective, imagery studies have been found to improve athletes' stress management skills, reduce anxiety, and strengthen mental resilience and self-efficacy. The literature also supports the fact that long-term and planned imagery programs have lasting and positive effects on athletes' self-perception and problem-solving skills.

In conclusion, this systematic review reveals that imagery should be considered not merely a complementary technique in sports, but an integral part of training programs. It is recommended that coaches, sports psychologists, and sports scientists plan imagery interventions appropriately for age, sport, and performance level; and that they particularly incorporate audiovisual and model-based applications. Future research involving larger sample sizes, long-term follow-up studies, and comparative examinations of different imagery models will make significant contributions to the literature.

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CHAPTER 3

THE EFFECT OF AUTOMATIC NEGATIVE THOUGHT PATTERNS ON PERFORMANCE IN ATHLETES

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Introduction

Sporting performance is a complex process in which mental and psychological factors have a decisive influence on performance that cannot be explained solely by physical, technical, and tactical competence (Weinberg & Gould, 2020). While many coaches focus on physical, technical, and tactical competencies during the competition preparation process, mental and psychological preparation is often overlooked. This situation causes athletes to experience higher levels of cognitive anxiety under performance pressure, consequently leading to a decline in performance.

High cognitive anxiety during the sporting performance process causes competition anxiety to be felt at a higher level and prevents athletes from reaching their ideal performance state. In the competitive atmosphere, where high competition requires athletes to process information coming from both inside and outside very quickly and respond, athletes can use automatic thinking patterns as a practical way to cope mentally. The way athletes perceive and react to the rapidly changing events around them and process information can bring about systematic thinking errors along with these automatic thought patterns, which directly affect the athlete's emotions and behaviour. Indeed, Beck (2011) has demonstrated in his cognitive theory that negative automatic thought patterns cause individuals to perceive their experiences in a distorted manner and, consequently, to form dysfunctional responses. Beck defined these automatic negative thought patterns as cognitive assessments that arise independently of the individual's efforts and mostly contain negative interpretations that are far from reality (Beck, 2011).These are patterns that distort reality, negatively affect performance, and create thought traps that eventually become cognitive beliefs, possessing a cyclical mechanism of operation. In other words, once formed in the athlete's mind, they continuously generate new negative thought patterns. Athletes experience fear of making mistakes, high anxiety, and stress due to these thoughts, which leads to a decline in performance, overtraining, and, if no support is provided, even quitting the sport. These thought traps, also defined in the literature as cognitive distortions, can be observed in different forms due to the performance-oriented, highly competitive atmosphere of sport (Hatzigeorgiadis & Biddle, 2008).

1. Negative Automatic Thought Patterns

1.1.Catastrophising

This is when an athlete perceives a minor mistake as a catastrophe or a major failure. Catastrophising thought patterns, which we observe in typical thought patterns such as 'I passed badly, I ruined the match', 'I made a mistake, we're definitely going to lose', 'If I miss the shot, everyone will laugh at me', will cause the athlete to lose focus and strive to make their thoughts a reality.

1.2.Overgeneralisation

This can be described as the tendency to make negative assessments about one's entire performance based on a single mistake, generalising the mistake.

The tendency to overgeneralise can be seen in negative thought patterns such as 'I played very badly in the last match, so I will play badly in this match' or 'I missed the penalty in the previous match, so I will miss the next penalties too; I am not as good as I used to be.'

1.3.Mind Reading

Refers to the athlete's unrealistic assumptions that others have negative thoughts about them. For example, negative thought patterns such as 'I missed the shot in the match, my coach definitely hates me', 'My teammates are definitely angry with me because of my poor technique in the competition', 'The fans will never forgive me for failing to save the ball' can be described as mind reading independent of reality.

1.4.Dichotomous Thinking

This can be described as the athlete viewing their performance as either completely successful or completely unsuccessful. For example, negative thought patterns such as 'I will either succeed or fail miserably' or 'If I'm not perfect, then I'm terrible' represent a one-dimensional assessment of the situation as black or white. Another example would be a gymnast perceiving a single mistake in their routine as if they had performed the entire routine poorly.

1.5.Personalisation

 This is when the athlete attributes all negative situations solely to themselves, taking responsibility for everything that goes wrong. Typical examples of personalisation include thoughts such as 'the team lost the match because of me' or 'I could have prevented the ball from going out despite the wind'.

1.6.Labelling

This is when an athlete perceives a mistake they have made as a reflection of their identity. For example, an athlete labelling themselves negatively with statements such as 'I am a talentless athlete', 'I always fail under pressure anyway', or 'I have low self-confidence' can be considered an example of labelling.

1.7.Perfectionism

This is when the athlete sets unrealistically high standards for themselves. Negative thought patterns such as 'I must not make any mistakes,' 'All my shots must be perfect,' and 'I must always be the best on the team and impress the coach' can be considered examples.

1.8.What-if Thinking

This is when the athlete constantly focuses on negative possibilities before a performance. Focusing on thoughts such as 'What if I get injured?', 'What if I embarrass myself?', or 'What if the goalkeeper misses the ball?' are examples of this situation.

1.9.Filtering

This refers to athletes filtering out negative feedback and focusing only on the negative aspects. For example, when a coach gives feedback on the skills an athlete needs to improve, the athlete ignores the positive aspects and focuses only on the negative aspects. This is a result of this perspective. Over time, this can lead to the athlete becoming obsessed with criticism.

1.10.Excessive Responsibility

Taking on responsibility is a particularly common cognitive distortion in team sports. It is the tendency for athletes to attribute every positive or negative outcome in the team to themselves. A volleyball player attempting to be both a setter and a defender is a good example of this. Statements such as 'The fate of this match depends on me' or 'If I make a mistake, the whole team will be ruined and we will lose the match' are examples of thoughts resulting from this cognitive distortion.

1.11.Negative Future Prediction

This is when the athlete has a perception that they will perform poorly before even demonstrating their performance. For example, an athlete thinking before a competition, 'I'm not in good shape today, I'll definitely lose,' or 'My opponent is too strong, there's no way I can win,' are examples of this type of cognitive distortion.

1.12.Comparison-based distortion

Especially in team sports, athletes constantly compare themselves to other players on the team, leading to overtraining and feelings of exhaustion. Statements such as 'Everyone on the

team is better than me' or 'I can never be like him' are examples of this type of cognitive distortion.

2.Causes of Incorrect Automatic Thought Patterns in Athletes and Their Effects on Performance

The use of incorrect automatic thought patterns has a multidimensional structure that can be explained by the convergence of many factors. The athlete's genetic and psychological characteristics, the socio-cultural characteristics of their environment, the performance pressure arising from the competitive nature of the sporting atmosphere, perfectionist training, insufficient self-confidence, past unsuccessful experiences, and pressure from coaches all play a role. -cultural environment, performance pressure arising from the competitive nature of the sporting atmosphere, perfectionist training, inadequate self-confidence, past failures, pressure from coaches, expectations from family, society and coaches, and inadequate psychological skills and conscious awareness can cause cognitive distortions in athletes.

2.1.Performance Pressure and Outcome-Focused Approach

The competitive structure of the sporting environment in which the athlete finds themselves increases their tendency towards catastrophic thinking under score-focused performance pressure, and perfectionist expectations rise even further. The athlete's belief that they must win the match, otherwise feeling worthless, can be described as the most obvious indicator of this situation. Indeed, Gould & Urdy (1994) and Beilock and Carr (2001) have demonstrated in their studies that outcome-focused goals increase anxiety in athletes and increase the tendency to use negative automatic thoughts.

2.2.Perfectionist Tendencies

 No matter how well an athlete performs, constantly setting higher, unattainable standards for themselves increases the tendency to use negative automatic thought patterns. When athletes make mistakes, they feel worthless and insignificant as a result of perfectionism, which is a consequence of negative automatic thought patterns that emerge in athletes. Indeed, Flett & Hewitt (2002) found that perfectionist tendencies increase the use of negative automatic thought patterns in athletes, leading to catastrophising and overgeneralisation.

2.3.Low Self-Confidence and Self-Perception

 Valey (2007) states that athletes with low self-confidence tend to use negative automatic thought patterns more frequently and perceive them as real. Internal dialogue such as 'My opponent is stronger than me, I will definitely lose' causes a vicious cycle in athletes that lowers their self-confidence and consequently their performance.

2.4.Past Failed Experiences

The athlete's acceptance of a past negative experience as a reflection of their entire performance leads to these cognitive distortions becoming permanent over time. Hanton, Mellalieu & Williams (2015) found that athletes with traumatic competition experiences exhibited more cognitive distortions in their behaviour. The study also indicates that past negative experiences increase the use of overgeneralisation and negative automatic thought patterns.

2.5.Coach Pressure and a Critical Training Culture

How athletes are trained is another factor that influences their internalisation of negative automatic thought patterns. An overly authoritarian and critical coaching attitude emerges as a factor that increases the tendency to use negative automatic thought patterns in the form of mind reading or overgeneralisation. Indeed, Smith, Smoll & Cumming (2007) found that athletes who constantly receive negative feedback from their coaches experience higher levels of anxiety, which in turn increases their tendency towards negative automatic thoughts.

2.6.Family and Social Expectations

Another factor that increases the athlete's anxiety and negative automatic thought patterns is the expectation of perfect performance from both the athlete's family and the socio-cultural environment in which they live. This causes the athlete to exert more effort to avoid disappointing their family and those around them, leading to higher performance pressure. Indeed, Harwood & Knight (2015) found in their research that family pressure increases performance anxiety, particularly in young athletes, and causes cognitive distortions.

2.7.Insufficient Psychological Training

As a result of the care shown in developing athletes' physical abilities during their training process, but not in developing their mental and psychological abilities, many athletes do not have the opportunity to sufficiently develop their awareness of their feelings and thoughts. Therefore, they may not be sufficiently aware of the effect that negative feelings and thoughts have on their performance. Indeed, Jones (1995) has demonstrated through research findings that athletes who do not receive mental skills training tend to use negative automatic thought patterns more frequently. The study also observed that young athletes, in particular, tend to perceive their situation as learned helplessness because they are unable to sufficiently develop their mental skills to control their situation.

2.8.The Highly Competitive Environment of Sport

Davis & Jones (2014) revealed in their studies that the highly competitive environment specific to sport increases athletes' tendency to constantly compare themselves to others and engage in negative self-talk. Athletes' false belief patterns that others on the team are better than them create an effect that threatens performance.

3.How Can Negative Automatic Thought Patterns Be Prevented?

In the highly competitive environment of sport, athletes' intensive use of negative automatic thought patterns causes them to misprocess information about the competition atmosphere and engage in cognitive distortions, leading to a loss of focus (Wilson et al., 2009; Eysenck et al., 2007), and make incorrect decisions based on incorrect information, which prevents them from quickly forming the correct responses at critical moments. Once this situation becomes a recurring cycle, the anxiety felt about the competition atmosphere gradually increases and turns into performance anxiety. This vicious cycle can lead to the athlete withdrawing from the sporting environment. Athletes need practical tools to prevent these negative automatic thoughts. Some of these are outlined below.

3.1.Cognitive Restructuring

Cognitive restructuring can be described as the athlete replacing their incorrect and dysfunctional thoughts with new, realistic and functional ones. An example of cognitive restructuring would be the athlete replacing the thought 'I made a mistake, I'm terrible' with the thought 'I made a mistake, but my performance is not entirely defined by this mistake'.Turner & Baker (2014) found that cognitive restructuring-based approaches reduced performance anxiety and increased cognitive flexibility in athletes. In another study, Hatzigeorgiadis et al. (2011) found that cognitive restructuring reduced anxiety and improved performance.

3.2 Positive and Functional Self-Talk

This refers to athletes consciously engaging in positive, functional internal dialogue with themselves to change dysfunctional negative thoughts. Examples of functional self-talk include an athlete who notices their attention wandering during competition directing themselves with statements such as 'focus,' 'my opponent is strong, but I am well prepared,' or 'do your best.' Indeed, there are studies in the literature that reveal the positive effects of functional positive self-talk on competition anxiety and performance (Koruç et al., 2021; Tod & Hardy, 2011; Hatzigeorgiadis et al., 2011).

3.3.Mindfulness

Mindfulness, which can be described as the mind focusing on the present moment without any intervention, can be expressed as the mind learning to observe thoughts. It prevents the athlete from forming emotional responses to experiences by increasing their momentary awareness and enables the control of reactions through mindfulness.

3.4.Breathing Techniques

Breathing exercises, which can be performed for various reasons such as improving cognitive skills, coping with stress, reducing anxiety, and increasing focus, can be considered another method athletes can use to reduce both anxiety and the intensity of negative automatic thought patterns (İlhan & Coşkun, 2024; Esenkaya, 2025). Diaphragmatic breathing, box breathing, controlled breathing, breath holding, and slow exhalation techniques in athletes have the effect of increasing mental focus, activating the sympathetic nervous system, thereby reducing negative automatic thought patterns and improving performance.

3.5.Pre-Performance Routines

Pre-performance routines in athletes are an important factor in stabilising the mind and reducing the intensity of negative automatic thought patterns. For example, an athlete with high competition anxiety creating rituals such as 3 deep breaths + positive self-talk + a movement rhythm allows the mind to move away from anxiety and also creates a preventive effect against cognitive distortions, thereby increasing performance. Indeed, Cotterill (2011) presented findings in their study indicating that routines reduce performance anxiety.

3.6.Creating Thought Diaries or Cognitive Recording Forms

Establishing the habit of recording emotions and thoughts in athletes reduces performance anxiety by developing conscious awareness. The athlete's deep reflection on the event creates an effect that reduces the intensity of negative automatic thought patterns. Thought diaries include sections on the event, the negative thought pattern it created, the feelings it evoked, alternative thoughts, and the outcome of the event. Hanton & Mellalieu (2015) research has shown that thought records are effective in stress management and reduce cognitive distortions.

3.7.Self-Confidence Development Programmes

Focusing on small successes and developing goal-oriented thinking skills enables athletes to focus on the controllable process rather than the score, thereby enhancing their problem-solving and coping skills and increasing their self-confidence. In this process, internal dialogue such as 'I am maintaining my technique and tempo' instead of 'I must win' increases

performance and reduces the intensity of catastrophic thinking patterns, which in turn creates an effect that increases self-confidence. Studies by Yıldız & Yılmaz (2019), Kingston & Hardy (1997) and Valey (2007) have shown that as self-confidence increases, performance anxiety and catastrophising decrease.

3.8. Family Education and Social Support

The family and the social environment should develop a process-oriented perspective towards the athlete rather than performance pressure, which reduces the performance anxiety felt by the athlete. Harwood & Knight (2015) found that athletes with supportive parental attitudes were less likely to use negative thought patterns. Another study revealed that athletes with supportive family attitudes tend to set process-oriented goals more frequently, which also reduces their tendency to catastrophise and their performance anxiety (Kingston & Hardy, 1997).

3.9. Improving Coach-Athlete Communication

Coaches are the strongest source of feedback and approval for athletes. As an authority figure who shapes the athlete's cognitive, affective, and psychomotor skill framework, the coach determines the athlete's performance anxiety and shapes their self-perception. Mageau & Vallerand (2003) found that the coach's communication style is one of the most important factors determining the athlete's automatic thought patterns, self-worth perception, and how they interpret their mistakes. Therefore, coaches should focus on providing process-oriented feedback and creating a safe psychological atmosphere in their communication with athletes. Indeed, Smith, Smoll, and Curtis (1979) found that athletes trained by coaches who used supportive communication language developed lower performance anxiety, a tendency to use fewer negative automatic thought patterns, and higher self-confidence.

Zourbanos et al (2013) found that coaches using motivational language increased the frequency of positive self-talk among athletes and reduced their tendency to use negative automatic thinking patterns. Similarly, Rees & Hardy (2004) found that coaches who used positive communication language increased athletes' perception of social support, which in turn improved the athlete's emotional regulation skills, increased cognitive flexibility, and reduced competition anxiety. The studies by Altıntaş & Akalan (2008) and Kaya & Yıldız (2020), which reveal the effect of supportive communication perception on athletes, also demonstrate the impact of the coach's motivating positive communication style. In short, coach-athlete communication can be described as an important regulator or trigger of athletes' use of negative automatic thought patterns.

Discussion and Conclusion

Whichever negative automatic thought pattern is used, it causes the athlete's anxiety, stress and fear of failure to increase, leading to a loss of focus. The resulting deterioration in attention leads to a decline in confidence and, consequently, performance. After a while, this cycle becomes a vicious circle and leads to a negative process that can result in the athlete giving up the sport. In this process, the athlete, the coach and the family all have important roles to play.

Establishing a cyclical feedback routine between the coach and the athlete will make a significant contribution. Indeed, incomplete mental schemas have an effect that causes cognitive distortions. It would be advisable to avoid using feedback that contains guidelines and questions with uncertainty that could trigger negative automatic thought patterns. This will help the athlete create new schemas for new inquiries that will answer their questions about the process and end questioning the process in their mind. In this process, it is also important for the coach and family to adopt a process-oriented approach.

Mindfulness exercises aimed at helping athletes recognise the linear relationship between the intensive use of negative automatic thought patterns and performance anxiety will also develop their skills in using questioning techniques. In particular, recognising common cognitive traps, developing behavioural strategies using cognitive restructuring processes, ensuring the athlete's development is evaluated systematically with concrete criteria, and using cognitive behavioural therapy tools will be an important step in helping athletes control and change their negative automatic thought patterns.

The athlete must be in a state of mental ease in which they can play the game in their mind. Negative automatic thought patterns creating mental confusion that hinders this and causing them to perceive reality differently are among the most significant obstacles to the athlete realising their potential. In this context, the key to good athletic performance can be considered an important tool that can turn competition into an advantage, is fully focused, and is relaxed enough to create the ideal performance state, carrying the athlete to the ideal performance state. In future studies, the inclusion of cognitive-behavioural-based psychological skill modules in coach training programmes to reduce the use of negative automatic thought patterns in athletes will contribute significantly to both performance and athlete well-being.

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CHAPTER 4

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN ACCEPTANCE AND ATTITUDES TOWARDS ARTIFICIAL INTELLIGENCE AMONG STUDENTS IN THE DEPARTMENT OF PHYSICAL EDUCATION AND SPORT

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Introduction

The current century is characterised as a digital age in which developments, changes, and transformations are experienced intensively in all fields (Bingöl, 2025; Okun, 2022). In line with this, researh highlights that artificial intelligence creates opportunities and conveniences in the field of education (Ali et al., 2025; De Freitas et al., 2023; Kaya et al., 2025; Manyika et al., 2017; Stein et al., 2024). Gansser and Reich (2021) define artificial intelligence simply as a technology developed to facilitate human life. They also state that it is designed to assist individuals in certain situations. Artificial intelligence plays a significant role in the teaching–learning process. Its potential to provide easy access to the information needed and desired by both teachers and students in educational programs, instructional methods, and assessment designs may yield significant outcomes in terms of ensuring effective learning (Al Darayseh, 2023; D'Mello & Graser, 2012; Hwang & Tu, 2021; Mahmoud, 2020). It is emphasised that artificial intelligence offers numerous opportunities and conveniences for educational processes, such as online learning environments, analyses of students' performance, and the provision of individualised methods for students by developing learning strategies through e-learning systems (Bulut et al., 2024; Hwang & Tu, 2021; Raffaghelli et al., 2022). Çam et al. (2021) state that artificial intelligence applications are used in educational processes to encourage long-term learning and to increase students' interest in lessons. Accordingly, students' individual learning experiences can be enhanced by learning platforms supported by artificial intelligence (Kış, 2019). It has been reported that an instructional process structured in this way can offer solutions aimed at ensuring long-term learning, effective teaching, increasing interest in lessons, and improving the quality of education (Taşçı & Çelebı, 2020; Tomczyk & Majkut, 2025). Moreover, learning platforms supported by artificial intelligence technologies may serve as an effective way to enable students to experience individualised learning and personalise the learning process (Dahri et al., 2024; Kış, 2019; Nabiyev & Erümit, 2020). In this context, it is emphasised that increasing the levels of acceptance of artificial intelligence in educational environments can help successfully integrate artificial intelligence applications into learning processes. This would enrich pedagogical practices in terms of quality (Batuk et al., 2025; Hwang et al., 2020). At the same time, it has been stated that more efficient working and learning tools can be provided to candidate teachers by artificial intelligence applications (Cengiz & Peker, 2025). The widespread adoption of artificial intelligence in education and its numerous benefits depend not only on technological developments, but also on users' acceptance and adoption of these technologies (Avcı, 2024; Fosso Wamba et al., 2024). Moreover, artificial intelligence also enables rich interactions. Research has shown that acceptance and use of new technologies differ according to gender (Gefen & Straub, 1997; Schermerhorn et al., 2008; Wang et al., 2009; Zhang et al., 2023). However, Chalutz Ben-Gal (2023) found that gender and educational levels did not influence people's acceptance or usage of artificial intelligence. Research into people's attitudes towards artificial intelligence has found that men tend to have more positive views on its use than women (Fieatta et al., 2021; Kim & Lee, 2024; Schermerhorn et al., 2008; Zhang & Dafoe, 2019). Individual barriers such as attitudes, digital competence, perceived usefulness and the perceived impact of artificial intelligence on teaching and learning activities may hinder the acceptance of artificial intelligence (Choung et al., 2023). The development of positive attitudes towards artificial intelligence among candidate teachers is facilitated by their acceptance of it (Cengiz & Peker, 2025). The use and adoption of technology is also said to be influenced by people's attitudes towards it (Avcı, 2024). Furthermore, since the attitudes of candidate teachers towards educational technologies incorporating artificial intelligence may have a potential impact on their future students' learning outcomes, it is considered important to gain further insight into the acceptance of artificial intelligence by candidate teachers (Zhang et al., 2023). It is thought

that the levels of acceptance of artificial intelligence and attitudes towards it among candidate physical education teachers influence their use of these technological opportunities. Therefore, identifying candidate teachers' levels of artificial intelligence acceptance and their attitudes toward it is essential for ensuring the effective use of artificial intelligence in educational contexts. The aim of this study is to compare the acceptance levels and attitudes toward artificial intelligence among candidate physical education teachers according to gender and grade level, and to examine the relationship between these acceptance levels and attitudes.

Method

Research Model

This study was designed as a descriptive research study employing a correlational survey model. Descriptive research aims to systematically and accurately describe existing conditions, whereas correlational studies examine the relationships between two or more variables without manipulating variables or being influenced by external factors (Fraenkel et al., 2012).

Participants

The participants of the study consisted of 92 physical education teacher candidates enrolled in the Department of Physical Education and Sports, including 45 females and 47 males. The mean age of the female participants was 20.02 years (*SD*= 1.38), the mean age of the male participants was 20.25 years (*SD*= 2.00), and the overall mean age of all participants was 20.14 years (*SD*= 1.72).

Data Collection Instruments

Data were collected using three instruments: the Personal Information Form, the Artificial Intelligence Acceptance Scale–Short Form*,* and the Artificial Intelligence Attitude Scale–Short Form*.*

Personal Information Form: The Personal Information Form, developed by the researchers, included questions about the participants' age, gender, and grade levels.

Artificial Intelligence Acceptance Scale Short Form: The Artificial Intelligence Acceptance Scale-Short Form developed by De Winter et al. (2024), was translated into Turkish by Batuk et al. (2025). It is a 5-point Likert-type scale. While calculating the total score, items 4, 5, and 6 were reverse-coded. The scale items range from Strongly Disagree (1) to Strongly Agree (5). The minimum and maximum possible scores on the scale were 1 and 5, respectively. Higher scores on the scale indicate a higher levels of acceptance of artificial intelligence. The Cronbach's alpha reliability coefficient of the scale was reported as .76, and in the current study, it was calculated as .72.

Artificial Intelligence Attitude Scale Short Form: The Artificial Intelligence Attitude Scale–Short Form, developed by Grassini (2023), was translated into Turkish by Kaya et al. (2025). The scale is a 10-point Likert-type instrument consisting of four items. The items range from Strongly Disagree (1) to Strongly Agree (10). Higher scores on the scale indicate a more positive attitude toward artificial intelligence. The Cronbach's alpha reliability coefficient of the original scale was .83, that of the Turkish version was .85, and it was calculated as .87 in the present study.

Data Collection Process

Before the commencement of the study, ethical approval was obtained, and official permission was granted by the institution where the data were to be collected. Following this, permission was granted by the instructors of the relevant courses attended by the candidate physical education teachers. During a designated part of the class, the instructors provided the students with information about the study, and the data collection instruments were administered to participants who voluntarily agreed to take part.

Data Analysis

The data obtained in this study were analyzed using IBM SPSS (Statistical Package for the Social Sciences) Statistics 21.0. Normality tests indicated that the data showed normal distribution. The independent samples *t*-tests were conducted for pairwise comparisons, one-way analysis of variance (ANOVA) was used for comparisons among more than two groups, and Pearson correlation analysis was performed to examine the relationships between variables.

Results

An independent samples *t*-test examined whether there was a statistically significant difference in artificial intelligence acceptance levels between male and female physical education teacher candidates. The findings indicated that artificial intelligence acceptance levels did not vary by gender. Both female ($\bar{x}$= 3.26, *SD*= 0.55) and male ($\bar{x}$= 3.42, *SD*= 0.69) teacher candidates demonstrated moderate levels of artificial intelligence acceptance [*t*(90)= -1.208, *p*> .05]. The detailed results of the analysis are presented in Table 1.

Table 1. Comparison of Artificial Intelligence Acceptance Levels of Physical Education Teacher Candidates by Gender

Gender	*n*	$\bar{x}$	*SD*	*t*	*p*
	45	3.26	.55		
Female				-1.208	.23
Male	47	3.42	.69		

An independent samples *t*-test examined whether attitudes toward artificial intelligence differed between male and female physical education teacher candidates. The findings showed no significant difference in artificial intelligence attitude levels between female ($\bar{x}$= 6.68, *SD*= 2.05) and male ($\bar{x}$= 6.93, *SD*= 1.93) teacher candidates. Both groups exhibited above-average attitudes toward artificial intelligence [*t*(90)= -.609, *p*> .05]. The detailed results of the analysis are presented in Table 2.

Table 2. Comparison of Artificial Intelligence Attitude Levels of Physical Education Teacher Candidates by Gender

Gender	*n*	$\bar{x}$	*SD*	*t*	*p*
Female	45	6.68	2.05	-.609	.54
Male	47	6.93	1.93		

An ANOVA was conducted to examine whether artificial intelligence acceptance levels differed among physical education teacher candidates across different grade levels. The

findings indicated that there was no statistically significant difference in artificial intelligence acceptance according to grade levels (1st grade: $\bar{x}$= 3.61, SD= 0.64; 2nd grade: $\bar{x}$= 3.46, SD= 0.56; 3rd grade: $\bar{x}$= 3.18, SD= 0.62; 4th grade: $\bar{x}$= 3.21, SD= 0.62). Overall, the results suggest that teacher candidates' artificial intelligence acceptance levels were above average ($F(3, 88)$= 2,537, p> .05). The detailed results of the analysis are presented in Table 3.

Table 3. Comparison of Artificial Intelligence Acceptance Levels of Physical Education Teacher Candidates by Grade Levels

Grade Levels	n	$\bar{x}$	SD	F	p
1st Grade	20	3.61	.64		
2nd Grade	21	3.46	.56	2.537	.06
3rd Grade	34	3.18	.62		
4th Grade	17	3.21	.62		

A one-way analysis of variance (ANOVA) was conducted to investigate whether attitudes toward artificial intelligence differed among physical education teacher candidates across different grade levels. The findings revealed no statistically significant differences in artificial intelligence attitudes based on grade levels. Moreover, teacher candidates across all grade levels demonstrated above-average attitudes toward artificial intelligence (1st grade: $\bar{x}$= 7.33, SD= 1.49; 2nd grade: $\bar{x}$= 6.76, SD= 2.16; 3rd grade: $\bar{x}$= 6.59, SD= 2.15; 4th grade: $\bar{x}$= 6.69, SD= 1.95) ($F(3, 88)$= .619, p> .05). The detailed results are presented in Table 4.

Table 4. Comparison of Artificial Intelligence Attitude Levels of Physical Education Teacher Candidates by Grade Levels

Grade Levels	n	$\bar{x}$	SD	F	p
1st Grade	20	7.33	1.49		
2nd Grade	21	6.76	2.16	.619	.60
3rd Grade	34	6.59	2.15		
4th Grade	17	6.69	1.95		

A Pearson correlation analysis was conducted to investigate the relationship between physical education teacher candidates' acceptance of artificial intelligence and their attitudes toward artificial intelligence. The findings revealed a moderate positive correlation between artificial intelligence acceptance and attitudes toward artificial intelligence (r= .45, p= .01), indicating that higher levels of artificial intelligence acceptance are associated with more positive attitudes toward artificial intelligence. The detailed results are presented in Table 5.

Table 5. The Relationship Between Physical Education Teacher Candidates' Acceptance of Artificial Intelligence and Their Attitudes Toward Artificial Intelligence

		Attitudes Toward Artificial Intelligence
Acceptance of Artificial Intelligence	r	.45
	p	.001

Discussion

The purpose of this study was to make a comparison between the levels of acceptance of artificial intelligence and the attitudes of physical education teacher candidates toward artificial intelligence, both in terms of gender and grade level. The study revealed no differences in physical education teacher candidates' acceptance levels or attitudes toward artificial intelligence based on gender or grade level. Additionally, a moderately positive relationship was identified between artificial intelligence acceptance and attitudes toward it.

Regarding this issue, Fietta et al. (2021) found that women held more negative attitudes toward artificial intelligence than men. There is a lack of alignment between this finding and the results of the present study. Similar to this study findings, it was found by Chalutz Ben-Gal (2023) that the willingness to use artificial intelligence-based applications was not affected by gender. Similarly, it was determined by Kaya et al. (2024) that no difference in attitudes toward artificial intelligence was found between male and female individuals. This finding is consistent with the present study's result that artificial intelligence acceptance levels of physical education teacher candidates did not differ by gender. The tendency to use or not use an application is related to its capacity to facilitate the task (Özkaynar, 2024). The lack of gender differences in artificial intelligence acceptance among physical education teacher candidates may be due to the perceived usefulness of artificial intelligence applications in education, influenced by factors such as technology integration and artificial intelligence's potential to enhance teaching and learning (Zhang et al., 2023).

It has been stated that new technologies provide numerous benefits; however, people tend to resist them (Choung et al., 2023; De Freitas, 2023). The recent impact of artificial intelligence in every area of life shows that educators' attitudes are key to the use of artificial intelligence in education (Aksekili & Kan, 2024). Similarly, the study reported that attitudes toward artificial intelligence among physical education teacher candidates did not differ by gender. Doğan et al. (2023) discovered that university students' attitudes towards artificial intelligence were not influenced by gender in their study on Sports Sciences students. Similarly, in a study conducted in the USA, it was found by Stein et al. (2024) that attitudes toward artificial intelligence did not differ by gender, and similar attitudes toward artificial intelligence were found to be held by both women and men. In their 2025 study, Köseoğlu and Köse (2025) discovered that adults' attitudes towards artificial intelligence remained consistent regardless of gender or educational background, with both men and women exhibiting a positive attitudes. The present study's findings are in line with those of previous research. It was stated by Özkaynar (2024) that positive attitudes toward artificial intelligence are created and a strong desire to adopt and use these technologies is generated by the opportunities and conveniences offered by artificial intelligence applications. The fact that physical education teacher candidates have similar attitudes to artificial intelligence might suggest that they are well aware of how artificial intelligence could be used. The absence of differences in attitudes may also be related to the fact that the perceived benefits of artificial intelligence applications in education do not vary by gender, with the result that there is a lack of gender disparity in perceptions of these benefits (Katsantonis & Katsantonis, 2024).

The study found that there was no difference in acceptance levels or attitudes towards artificial intelligence among physical education teacher candidates according to their grade level. The study by Chalutz Ben-Gal (2023) found no difference in acceptance of artificial intelligence applications according to educational grade level. Similarly, it was determined by Köseoğlu and Köse (2025) that attitudes toward artificial intelligence did not differ according to education level, which is consistent with the findings of the present study. The fact that there were no differences in acceptance or attitudes towards artificial intelligence among physical

education teacher candidates at different grade levels may be related to the fact that no education focused on artificial intelligence has been provided at any grade level. Yeniçeri and Kenan (2025) found that teachers training to teach did not have different feelings about artificial intelligence depending on their grade level. They had similar attitudes toward artificial intelligence across all grade levels. Teo (2011) and Venkatesh et al. (2003) suggest that technology-related attitudes are more influenced by individual experiences and personal attitudes than by demographic variables. This may also explain why there are no differences in artificial intelligence acceptance and attitudes by grade level. Moreover, the university level is characterised by comparable access to and utilisation of technology, a factor that might also underlie this phenomenon (Yeniçeri & Kenan, 2025).

A moderately positive relationship was identified between acceptance of artificial intelligence and attitudes towards artificial intelligence among physical education teacher candidates. Research shows that people's attitudes towards artificial intelligence have a significant impact on their acceptance and usage of it (Kaya et al., 2024; Özkaynar, 2024). This finding supports the relationship between artificial intelligence acceptance and attitudes toward artificial intelligence among physical education teacher candidates. Kang et al. (2023) emphasized the relationship between awareness of digital technologies' acceptance, usage, and risks. They also emphasised the relationship with the development of positive attitudes toward artificial intelligence. It is also highlighted that one of the most important factors in teachers' adoption and use of artificial intelligence applications is perceiving these technologies as useful and easy to use (Balıkçı & Durak, 2025; Miller & Khera, 2017). The positive relationship between artificial intelligence acceptance and attitudes may be related to perceived usefulness, as artificial intelligence meets their needs and is easy to use, thereby influencing their positive attitudes and acceptance (Al Darayseh, 2023; Gökçe Tekin, 2024).

Conclusion and Recommendations

According to the results of this study it can be concluded that acceptance of artificial intelligence and attitudes toward it do not differ by gender or grade level among physical education teacher candidates, who generally hold similar attitudes and acceptance levels. The artificial intelligence acceptance of physical education teacher candidates and their attitudes toward artificial intelligence was found to be positively and moderately correlated. It is thought that the above-average artificial intelligence acceptance and positive attitudes towards artificial intelligence of physical education teacher candidates encourage them to conduct studies on this topic, acquire knowledge and develop themselves in this area.

As more experience and understanding regarding artificial intelligence is gained by physical education teacher candidates, improvements may also be seen in their acceptance and attitudes toward artificial intelligence. Therefore, educational programs should provide pre-service teachers with sufficient experience and training on the use of artificial intelligence-based educational tools. This will help them to understand the potential benefits (Venkatesh et al., 2003). This can help them develop a more profound understanding of technology and make informed decisions about its use in the classroom.

Comprehensive training programs that highlight and emphasize the potential benefits and practical applications of artificial intelligence technologies can be developed and systematically delivered to prospective educators. Such programs can equip teacher candidates with the necessary knowledge, skills, and confidence to effectively incorporate these emerging technologies into their professional practice, ensuring that they are able to leverage AI tools to enhance teaching and learning processes (Miao & Holmes, 2021). By providing structured guidance, practical examples, and hands-on experience, these training initiatives can support

teacher candidates in understanding both the theoretical and practical dimensions of artificial intelligence, thereby fostering a more seamless and informed integration of AI into educational settings. Furthermore, the acceptance, utilization, and attitudes of teacher candidates toward artificial intelligence can be significantly shaped by the policies and strategies implemented by education policymakers. By integrating artificial intelligence literacy into teacher education curricula, policymakers can create a supportive and enabling environment that encourages prospective educators to engage with AI technologies in a meaningful and informed manner (Dzerviniks, 2021). Such curriculum-based interventions can not only enhance candidates' technical competencies but also positively influence their perceptions, confidence, and willingness to adopt artificial intelligence tools in their future teaching practice. In this way, a combination of well-designed training programs and policy-driven curriculum integration can serve as a powerful mechanism for promoting both the effective use and the widespread acceptance of artificial intelligence within the field of education.

In future studies, the concerns and apprehensions of physical education teacher candidates regarding artificial intelligence can be examined in greater depth. Such investigations can aim to understand not only how these concerns are articulated but also the underlying factors that contribute to their formation. This may include exploring the personal, academic, and technological experiences of the candidates, as well as identifying the contextual or environmental influences that shape their perspectives toward artificial intelligence. By gaining understanding of these concerns, researchers can provide valuable insights into the specific challenges and uncertainties that teacher candidates face in integrating emerging technologies into their professional practice.

Additionally, the acceptance of artificial intelligence and the attitudes of physical education teacher candidates toward this technology can be studied in a detailed and systematic manner. Qualitative research methods, in particular, are highly suitable for such in-depth investigations, as they allow researchers to capture the subjective experiences, perceptions, and thought processes of individuals. Through qualitative approaches, it becomes possible to uncover the factors that drive positive or negative attitudes toward artificial intelligence, as well as the ways in which these attitudes may vary according to different personal, social, or educational contexts.

Furthermore, the level of artificial intelligence literacy among physical education teacher candidates can be assessed, providing a comprehensive understanding of their knowledge, skills, and competencies in this rapidly evolving field. The findings from such investigations can then be used to inform and enhance future teaching practices, curriculum design, and professional development programs. By identifying strengths and gaps in artificial intelligence literacy, educational institutions and instructors can develop targeted strategies to support teacher candidates in effectively integrating artificial intelligence tools and technologies into physical education instruction, ultimately contributing to more effective and innovative teaching practices in the field.

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CHAPTER 5

STEP COUNTING WITH PHYSICAL ACTIVITY TRACKERS

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INTRODUCTION

Accurately measuring physical activity is crucial for establishing and monitoring physical activity recommendations and for implementing public health interventions (Bort-Roig et al., 2014; Lorenz et al., 2015). Collecting epidemiological data, often through limited and reliable means, presents challenges (Yıldız and Temiz, 2022). Various methods are available to measure PA (Physical Activity) and SC (Step Count) in free-living settings. Subjective measures such as self-report tend to overestimate the time spent engaged in moderate- to vigorous-intensity PA (Kingsley et al., 2019). Accelerometer-based motion sensors have become a popular method for objectively measuring area-based PA and SC (Wijndaele et al., 2015). Furthermore, low-cost interventions to address physical inactivity in clinical and non-clinical populations that meet the demands of modern lifestyles are needed. Consumer devices that provide feedback to the user, such as wearable activity trackers, activity-tracking smartwatches, and pedometers, can meet this need (Ferguson et al., 2022).

Without the need for expensive laboratory-level equipment, implantable or portable electronic devices, using powerful microchips and smart sensors built using specialized algorithms, allow individuals to easily, inexpensively, and objectively monitor physical activity, such as step count and distance traveled, kilocalories, sleep, and other health-related metrics (Dobkin et al., 2018). Among these outputs, walking step and distance measurements remain the most popular and translatable outputs used today (Carlin and Vuillerme 2021).

With the increasing importance of these wearable devices for tracking physical activity and encouraging it, the reliability of these devices has become a subject of research, and numerous studies have been conducted. With walking being considered the most easily achievable physical activity, individuals' step counts and their adequacy have become a matter of interest. Steps are a fundamental unit of human movement and, therefore, a preferred metric for measuring physical activity. Steps are objective and specific. Because they are easily understood by everyone, they can be measured easily and accurately. They can be used to classify people into less active and more active categories. Steps have the potential to be useful in translating scientific findings into public health messages (Bassett et al., 2017).

A literature review shows that most adults take 4000-6000 steps in their regular daily activities and that the additional number of steps they need to gain from other moderate-to-vigorous activities should be between 3000-6000. This means approximately 10000 steps in total (Choi et al., 2007). According to Statista (2025) data, Hong Kong ranks first with 6880 steps, China ranks second with 6189, and Russia ranks third with 5969. Türkiye is above Australia and the United States with 5057 steps. In 2004, Tudor-Locke and Bassett determined preliminary physical activity cut-off points determined by a pedometer for healthy adults: 1) <5000 steps/day (sedentary); 2) 5000-7499 steps/day (low active); 3) 7,500–9,999 steps/day (somewhat active); 4) 10,000–12,499 steps/day (active); and 5) ≥12,500 steps/day (very active). These categories were consolidated in 2008 (Tudor-Locke et al ., 2009).

Although there are no guidelines regarding daily step count recommendations, Saint-Maurice et al. (2020) concluded that total daily step count may be more important than step intensity for improving health. Furthermore, a recent systematic review concluded that an increase of 1000 steps per day may help reduce the risk of all-cause mortality, cardiovascular disease morbidity, and mortality, as there is an existing inverse correlation between mortality risk and PA levels (Jayedi et al., 2022). In a study examining 12-month step count data obtained from pedometer programs installed on teachers' smartphones in Türkiye, it was

found that teachers' step counts It has been found that the frequency of hospital admissions decreases as the number of steps increases. Furthermore, the frequency of following a pedometer program was found to be positively proportional to the annual step count (Savdi and Yıldız, 2020). In this sense, a walking program based on step count assessed by a pedometer may motivate people to increase PA levels in the long term and may also provide health benefits for adults and the elderly (Harris et al., 2019). Step counting with fitness trackers has been reported to be associated with modest changes in variables such as body weight, blood pressure, and high-density lipoprotein (HDL) cholesterol (Chaudhry et al., 2006). These changes in body weight, blood pressure, and HDL cholesterol occur especially in sedentary populations that do not reach the basic PA guidelines, as this provides additional motivation to increase PA levels (Nuss et al., 2021).

PHYSICAL ACTIVITY TRACKERS

With the birth of the idea of producing devices for automatically counting steps, the Yamasa company in Tokyo, Japan, designed a manpo-kei pedometer in 1965. The motto of 10,000 steps per day emerged in Japan around 1965, shortly after the Tokyo Olympics. This was believed to be the amount of physical activity that would be sufficient to reduce the risk of coronary heart disease. The Yamasa company continuously improved its step counter, and in the 1990s, it produced the Digi-walker (DW-500), which featured a lever arm suspended from a hairspring, an electronic counter, and a digital display. Since 1996, measuring steps has become an accepted method for assessing physical activity in scientific research. Studies have shown that one pedometer (the Yamax DW-500) is more accurate and reliable than others. Around this time, other researchers began using pedometers for population surveillance and walking interventions (Bassett et al., 2017).

While measuring FA using accelerometers or pedometers is crucial in many research settings, high wear time compliance is essential for accurate assessment. Research-grade hip-worn accelerometers are often not used reliably enough to ensure adequate wear time compliance and, consequently, do not allow for accurate FA assessment. In recent years, wrist-worn activity trackers have gained popularity, appearing to have higher wear time compliance compared to hip-worn accelerometers due to their greater wearing comfort and the fact that participants are less likely to forget to remove or wear them day or night (Höchsmann et al., 2020).

Activity trackers are electronic wearable devices that monitor health-related metrics such as walking or running, heart rate, blood oxygen levels, calorie consumption, and sleep quality. They can translate human movement into various data formats. Most activity trackers provide estimates of steps, distance, and active minutes. Data can be viewed on a phone, tablet, or PC. Some trackers can even track sleep patterns and allow for tracking of eating habits. Most fitness trackers/activity trackers pair with another device, such as a smartphone, computer, app, or even a smart scale. Once paired, some trackers also provide alerts for text messages, phone calls, and emails (MHealthy, 2019).

Fitness and activity trackers most often come in the form of wristbands, but they can also appear as clip-on devices, earbuds, or smart fabric clothing. In addition to being a standalone device, a fitness app can also exist as software often installed on smartphones that uses the device's built-in components to track specific activities (Statista, 2022). Activity trackers are less expensive than smartwatches due to their less expensive hardware and generally fewer sensors. Accelerometers, the most commonly used sensor for measuring step movements, measure the acceleration of the human body's movement along one or more axes

(Sarcevic et al., 2019). Gyroscopes are also used to measure rotation of different body parts, often in conjunction with accelerometers (Kamisalic et al., 2018). They can be easily synced with a smartphone or computer app, allowing continuous PA measurement over weeks, months, or years (Hartung et al., 2020).

Due to the wide variety of wearable devices, various brands have developed their own apps, allowing users to visualize the compressed data recorded by their fitness trackers during a specific sporting or daily activity. Brands such as Apple, Xiaomi, and Fitbit have commercialized smartwatches and activity/fitness trackers that sync with Apple Health, Mi Fit, and Fitbit, respectively (El-Amrawy and Nounou, 2015). Today, most of these devices (e.g., Apple Watch, Fitbit Charge, or Mi Band) can record physical variables such as step count or activity intensity, sleep hours, and calorie expenditure. Physiological variables such as heart rate (HR) and heart rate variability (HRV) can also be monitored (Scalise and Cosoli, 2018).

Technological advances have led to the miniaturization of devices, extended battery life, the computation of various movement behaviors, and the calculation of vital sign measurements, all while making them affordable for large-scale studies, clinical applications, or individual consumers (Kastelic et al., 2021). In particular, low- cost wrist-worn consumer-based activity trackers have gained immense popularity over the past decade because they are considered attractive and convenient tools for increasing users' PA levels through instant feedback on their PA levels and lifestyle (Pérez et al., 2022).

SOME WEARABLE DEVICE FEATURES

Xiaomi Smart Band 9

The Xiaomi Smart Band 9 stands out among low-cost fitness trackers and is equipped with more advanced features than its previous versions. Its smaller (46mm), thinner, and lighter design enhances user comfort, while its aluminum-look casing and diverse color options offer an aesthetically pleasing look. Its 5 ATM water resistance makes it suitable for swimming and water sports. The device's 1.62-inch AMOLED display and 1200 nits of brightness enhance daylight readability and also supports always-on display mode. On the software side, it's compatible with the Mi Fitness app and integrates data with platforms like Apple Health, Google Fit, Strava, and Suunto.

Health and fitness tracking features include step count, sleep stages, stress level, heart rate, and SpO2 measurements, offering versatile use with over 150 sports modes. However, the device lacks built-in GPS; only the GPS connected to the phone can be used. Heart rate measurements have been observed to fluctuate within ±10 bpm, and accuracy is limited, particularly during exercise. Sleep measurements have been reported to tend to overestimate light and deep sleep periods. However, in terms of basic activity and health tracking, it meets user expectations.

In terms of battery performance, its 233mAh battery offers up to 21 days of battery life, but with notifications, sleep, and SpO2 measurements enabled, this lasts an average of 7-10 days. A full charge takes around an hour.

From an academic perspective, the Xiaomi Smart Band 9 is an accessible health and activity tracking device that appeals to a wide range of users. While it's particularly suitable for daily step counting, sleep tracking, and general health indicators, it has limited potential

for clinical studies or advanced sports science research requiring high accuracy. Therefore, while the device is a valuable option for individual users and general health awareness, it should only be used as a supplementary measurement tool in scientific research (Xiaomi Türkiye, 2025).

Huawei Band 9

Huawei Band 9 is a smart wristband highly suitable for daily use with its compact and lightweight design. Its 1.47-inch AMOLED screen and 194 × 368 pixel resolution provide a visual experience with highly readable and vibrant colors. Its durable polymer casing and 5 ATM water resistance make the device safe for both sports and daily use. The device is equipped with a 9-axis IMU sensor, optical heart rate sensor, and ambient light sensor, providing essential health data such as step count, heart rate, sleep tracking, and stress monitoring. Battery life is reported to be approximately 9 days with typical use and 14 days with maximum use; it can last approximately 3 days with Always On Display mode. Furthermore, a variety of straps and color options for different wrist circumferences increase user personalization options. Huawei Band 9's Bluetooth 5.0 support and Android/iOS compatibility simplify data synchronization and ensure reliable tracking of daily activities. Overall, the Huawei Band 9 stands out as a suitable option for both daily users and individuals who want to track light exercise, with its user-friendly interface, long battery life, and various health monitoring features (Huawei Türkiye, 2025).

Samsung Galaxy Fit3

Standing out with its stylish design, advanced health tracking features, and large display, the Galaxy Fit3 offers a powerful wristband experience for both athletes and those who embrace an active lifestyle. The band stands out with its large 1.6- inch AMOLED display. Its brightness ensures clear visibility even in sunlight. Its thin, aluminum body makes it lightweight and doesn't interfere with workouts. Speaking of workouts, the band supports over 100 different exercises and automatically detects frequent workouts, including running, cycling, rowing, and swimming. Being thin and lightweight, it also tracks sleep patterns without disturbing you. When the Samsung smart band detects a fall, it asks if the person needs help. In other emergencies, emergency contacts can be notified by pressing the home button five times (Donanimhaber, 2025).

Garmin Vivosmart 5

The Garmin smart wristband combines sports and health tracking with smart technologies. Standing out with its stylish design, advanced sensors, and long battery life, this model is the ideal companion for both daily use and athletic performance. Despite its bright screen, it offers up to 7 days of battery life. Advanced health sensors allow for 24-hour heart rate monitoring, blood oxygen saturation measurement with the Pulse OX sensor, advanced sleep analysis (light, deep, REM stages, sleep score), stress tracking, breathing exercises, menstrual cycle tracking, body energy level measurement, and more. Waterproof up to 5 ATM, it can be used comfortably in the shower, swimming, or in the rain (Donanimhaber, 2025).

Honor Band 6

The Honor Band 6 is a device that generally meets the "multifunctional health and activity tracking" features promised in its promotional materials; it offers distinct advantages, particularly in terms of screen size, battery life, and basic sensor functionality. The Honor Band 6 offers a wide and clear viewing experience with its 1.47-inch AMOLED screen and 194×368 pixel resolution. Thanks to Always-on Display support, the screen can remain on constantly, providing user convenience. With its 180 mAh battery capacity, the device can last 14 days with typical use and approximately 10 days with intensive use. Thanks to its 5 ATM water resistance, it can be used comfortably in swimming and water sports. The HONOR Band 6 offers health and lifestyle tracking features such as 24-hour heart rate and SpO_2 monitoring, sleep tracking, stress level measurement, and menstrual cycle tracking. It also enables tracking of various physical activities with more than 10 sports modes. Bluetooth 5.0 support and Android/iOS compatibility simplify data synchronization, while its lightweight and ergonomic design ensures comfortable use. The HONOR Band 6 stands out as a reliable smart bracelet for daily life and sports activities thanks to its large screen, long battery life, and versatile health monitoring features (Honor, 2025).

Amazfit Band 7

The Amazfit Band 5 is a smart band offering a wide range of sensors and features at an affordable price. It can offer a satisfactory user experience in terms of daily health tracking, activity management, and notification management. However, caution should be exercised, particularly in areas such as biometric accuracy, lack of GPS, and sync stability; measurements should be interpreted more as "trend indicators" rather than reference devices. The Amazfit Band 7 offers a wide and clear visual experience with its 1.47-inch AMOLED screen and 198×368 pixel resolution. Thanks to the Always-on Display feature, the screen can be always visible, which increases ease of use. The device, with its 232 mAh battery capacity, provides 18 days of battery life with typical use, 28 days in power saving mode, and approximately 12 days with intensive use. Its 5 ATM water resistance makes it suitable for swimming and water sports. More than 120 sport modes allow users to track different types of exercises. It also allows users to monitor their daily physical and biological states with 24-hour health monitoring features such as heart rate, SpO_2, stress level, and sleep tracking. Amazon Alexa integration and the Zepp OS operating system enhance the device's smart functionality, while its lightweight design and interchangeable strap options offer comfortable and customizable wear. With its large screen, long battery life, and versatile health tracking features, the Amazfit Band 7 stands out as a smart wristband suitable for daily life and sports activities (Amazfit Türkiye, 2025)

WIDESPREAD OF USE

Wearable devices, particularly smartwatches and smartbands, have played a significant role in health monitoring and daily living activities in recent years. Global wearable device shipments exceeded 325 million units in 2016, rising to 722 million units in 2019 and reaching 534.6 million units by 2024, with growth projected to continue at 4.1% in 2025 (IDC, 2025). The global wearable technology market is expected to be valued at US$70.3 billion in 2024, rising to US$84.5 billion in 2025 and reaching US$152.8 billion by 2029 (MarketsandMarkets, 2024).

Initially, there was a clear distinction between smartwatches and fitness trackers, which feature sensors that transmit activity data to a smartphone. However, today, devices like the

Apple Watch, with their advanced sensors and health-tracking features, are used more than just as watches; they are also comprehensive health and activity trackers (Scoop, 2025). Smart wristbands designed for fitness or activity tracking offer convenience for users with their compact design and long battery life, while also leading to a decline in the number of other dedicated activity trackers.

Market leaders include Apple, Xiaomi, Huawei, and Samsung. By 2025, Apple will hold 12% of the global market, Huawei 11%, Samsung 10%, and Xiaomi 9% (Scoop, 2025). Geographic differences also influence market share; for example, American and British consumers primarily prefer Apple devices, while Spanish users primarily use Xiaomi devices.

Fitness and health apps are further driving wearable device adoption. By 2023, apps like MyFitnessPal and Fitbit had reached millions of users and captured significant market share in terms of revenue (Sensor Tower, 2023). Furthermore, Home Workout was the most popular app, with 2.9 million downloads worldwide as of early 2022 (Statista, 2022). These apps help users plan their exercise routines, track their calorie intake, and monitor their overall health.

As a result, the wearable technology market continues to grow rapidly, driven by increased health awareness, technological innovations, and user-friendly applications. The increasingly blurred boundaries between smartwatches and wristbands, coupled with the diversification of app ecosystems, enable users to track their health and physical activity data in a more comprehensive and personalized way (IDC, 2025; MarketsandMarkets, 2024; Scoop, 2025).

Wrist-worn accelerometers are widely used as an objective measure of physical activity in cohorts in the UK, US, and Brazil (Doherty et al., 2017). Therefore, as the use of wearable activity trackers for both personal and scientific purposes increases, the validity and reliability of these devices are essential (Pérez et al., 2022).

ACADEMIC STUDIES

Despite the widespread sales and popularity of these wearable fitness trackers, which monitor physical activity and provide feedback over appropriate periods, over the past decade, evaluations of their usability, accuracy, or consistency remain inadequate (Bunn et al., 2018). While some independent validation protocols have been tested in laboratory and free-living conditions (Pérez et al., 2022), standardized protocols have also been produced that allow for the validation of these devices. In an attempt to develop a standardized validation process and certification, the Consumer Technology Association (CTA) developed a set of guidelines for the validation of wearable and/or app-based step counters. While a step in the right direction, the CTA's proposed protocol focused solely on controlled treadmill walking and running in healthy individuals and did not consider the validation of the technologies in free-living conditions and cohorts with varying gait characteristics. To address these concerns, The Towards Intelligent Health and Well-Being Network of Physical Activity Assessment (INTERLIVE) was created to develop a best-practice consumer wearable and smartphone step counter validation protocol (Johnston et al., 2021).

Significant efforts have been made to validate output measurements from consumer-based activity trackers. The performance of activity trackers varies significantly among different brands and models, as well as among the populations tested. In general, the accuracy of step counts is high in adults without mobility limitations. However, the validity for measuring PA, energy expenditure, and sleep ranges from poor to good. Most studies

focusing on step counts have been conducted under controlled conditions. While significantly most validation studies have included healthy young and middle-aged adults, the performance of activity trackers in older adults is a recent topic of research due to differences in walking patterns. To date, few validation studies have been conducted on wrist-worn consumer trackers that included older adult populations. Most studies have investigated steps and reported that step accuracy is generally high but deteriorates with slow walking or the use of walking aids (Kastelic et al., 2021).

A meta-analysis examined the usability of 423 wrist-worn fitness wearable devices from 132 different brands and analyzed the availability of their respective fitness sensors from 2011 to 2017, yielding significant results. Forty-seven percent of brands released only one device. New brand introductions peaked in 2014, with the largest number of new devices introduced in 2015. Sensor support has reportedly increased annually, with accelerometers and photoplethysmographs for heart rate estimation being the most common sensors. Of the currently available brands, the five most frequently used in research projects are Fitbit, Garmin, Misfit, Apple, and Polar. Fitbit has been used in twice as many validation studies as other brands and is registered in Clinical Trials 10 times more frequently than other brands. New devices and brands launched each year promise improved metrics and user experiences. At the same time, other brands are disappearing from the consumer market for various reasons. Improvements in device quality offer new opportunities for research. However, only a few well-established brands are frequently used in research projects, and even fewer are fully validated (Henriksen et al., 2018).

Among the brands most frequently studied for their validity, Fitbit, Apple, Jawbone, and Garmin are quite expensive and beyond the financial means of a significant segment of the population. Although a growing number of published studies evaluating well-known activity trackers have evaluated only a few low-cost activity trackers (Carlin and Vuillerme, 2021; Xie et al., 2018). Recent reviews indicate that some metrics for some activity trackers are sufficiently accurate to measure PA in research settings (Shin et al., 2019). Thus, the body of research examining the use of wearable activity trackers to measure and intervene in physical activity has expanded rapidly. However, despite their initial promise, there is still widespread skepticism about the effectiveness of wearable activity trackers within the scientific, medical, and general public (Ferguson et al., 2022).

The reliability of research-grade accelerometers, such as the StepWatch, an ankle-worn device, and the ActiGraph wGT3X+ research-grade accelerometer, worn on the hip or wrist, has been previously demonstrated under laboratory and free-living conditions. These devices are used as benchmarks for validating other consumer-grade fitness trackers (Höchsmann et al., 2020).

The Garmin Vivoactive 4s, a consumer-based activity tracker, has been reported to perform excellently for step count in healthy adults, with Mean Absolute Percentage Error (MAPE) within 1% for brisk walking and various running speeds (Wahl et al., 2017). When worn by older adults, the Garmin Vivoactive 4s demonstrated excellent accuracy during controlled walking at preferred pace, during leisurely walking, and during free-living conditions (Kastelic et al., 2021).

Initial studies involving the Fitbit focused on establishing its accuracy as an objective FA measurement tool, particularly when compared to existing gold-standard measurement devices. Overall, there are mixed findings regarding the accuracy of Fitbit measurements, with some studies demonstrating step count accuracy within 50% of those compared to

research-grade accelerometers, and some reporting high validity in step count measurements. The Apple Watch was evaluated in 6% (2/31) of studies using manual counting as the reference standard. The mean difference between the device and manual counting ranged from −47 steps to 39.44 steps across different walking conditions (St Fleur et al., 2021).

Of the Garmin Vivofit has been found to be high in many studies **,** with an error rate ranging from −41% to 18%. One study for the Vivofit 2 reported high validity with a MAPE of 4% (St Fleur et al., 2021). Specifically, if an activity tracker is to be used as an outcome measure in a clinical trial or as an alternative gold-standard measurement tool for step counting, it is recommended that the device demonstrate an extremely low level of measurement error (MAPE ≤5%). However, if the device is being validated for use in the general population, a marginally higher error (MAPE ≤10%–15%) is acceptable (Johnston et al., 2021).

ranged from -2.7% to 1.5% for the Garmin Forerunner 920XT, from -1.5% to 0.6% for the Garmin Vivoactiv , and from -1.1% to -0.3% for the Garmin Vivosmart HR. For the Garmin Vivosmart HR, the mean difference ranged from -39.7 steps to 5.4 steps for different walking speeds and locations (outdoors vs. indoor) over a total of 111–686 steps (St Fleur et al., 2021).

the Jawbone UP , the error rate was -6.73% in one study. For the Jawbone UP2, the mean difference across walking conditions ranged from 16.19 steps to 64 steps. For the Jawbone UP24 , the mean error percentage ranged from -28% to -0.8%. For the Misfit Shine , the error rate ranged from -13% to 23%. For the Mio Fuse , the error ranged from -5% to -16% across different treadmill speeds , while for the Polar Loop , it ranged from -13% to 27%. A Pearson correlation coefficient of 0.96 (P <.01) was reported for the Polar A300, while the Bland-Altman deviation for the V800 was found to be 2487 steps per day. For the Withings Pulse, the error rate for step count ranged from -16.0% to -0.4% and accuracy ranged from 97.2% to 99.9% (St Fleur et al., 2021).

Xiaomi, one of the brands that has increased its sales volume in the last decade, is currently among the top five brands with its Mi Band (MB) series, one of the most popular low-cost fitness trackers. For example, the Mi Band 4 (MB4) can record daily activity for approximately 21 days. Among other functions, the MB4 records step count and heart rate. Therefore, it is possible to use the MB4 to monitor exercise intensity and daily physical activity. The MB4 has reasonable validity and precision and can be used to monitor step count and heart rate averages in free-living conditions and in indoor and outdoor environments (Pérezve et al., 2022). Another study found a high validity rate for the Xiaomi Mi Band 2, with an average error percentage of <5% (St Fleur et al., 2021).

A study conducted in healthy adults in Türkiye analyzed the validity and reliability of step count (SC) estimation using two selected smart bracelets from leading wearable device vendors, Xiaomi (Mi4) and Huawei (H4), under controlled conditions, at both normal and fast walking paces. MAPE values recorded for the Mi4 and H4 smart bracelets were <5% for both male and female participants at both normal and fast walking paces, which was considered excellent. While the H4 device was found to be valid and reliable based on all analyses, the Mi4 device was found to be invalid and reliable at fast walking pace based on ICC and Pearson correlation analyses (Yıldız and Günel, 2023).

A major study comparing the accuracy and validity of two different activity trackers measuring step count in individuals after a stroke is evaluating the potential of these low-cost

devices for clinical and research applications. The primary objective of the study was to assess the criterion validity and accuracy of the ActiGraph and the Xiaomi Smart Band for measuring step count in individuals who have had a stroke. Fifty stroke survivors performed a 2-minute Walk Test wearing both devices. The observed step count was compared with the step count predicted by both devices. The effect of walking speed on the accuracy of these devices was also examined. A high correlation (rho = 0.83) was found between the anticipated and predicted step count with the Xiaomi Smart Band 7, and a MAPE ratio of 12% was found. This ratio decreased to 3% at high walking speeds and increased to 18% at low speeds. The study demonstrates that the Xiaomi Smart Band has good criterion validity and moderate-to-high accuracy in measuring step count after a stroke. Due to its low cost, this device can be used as an alternative to more expensive activity trackers. Providing reliable results, especially at low walking speeds, shows that it can be an effective tool in clinical rehabilitation processes and individual monitoring (Alvarenga et al., 2024).

In a systematic review, the accuracy of wrist-worn devices was evaluated across various parameters. Metrics such as step count, heart rate, and energy expenditure were among the most frequently evaluated parameters. For example, the Fitbit Charge and Charge HR models demonstrated a MAPE of less than 25% for step count measurements. The Apple Watch, on the other hand, had a MAPE of less than 10% for heart rate measurements. However, energy expenditure measurements showed low accuracy, with MAPE values above 30% across all devices. These findings suggest that while wrist-worn devices provide high accuracy in some parameters, they perform poorly in others. Acceptability is a parameter that indicates the extent to which devices are accepted and used by users. In this study, acceptability was generally assessed through device usage time and data availability. For example, the Fitbit Charge HR, Fitbit Flex 2, and Garmin Vivofit models offered data availability above 75%, while the GENE Activ and Nike Fuelband stood out with 89% usage time. These data indicate the extent to which the devices are accepted by users and the duration of their use in daily life. The accuracy and acceptability of wrist-worn devices can have significant implications for clinical and research applications. In particular, assessing physical activity levels plays a critical role in managing conditions such as cardiovascular health, metabolic syndrome , and obesity. High levels of accuracy and acceptability of these devices support reliable data collection in clinical practice and research (Germini et al., 2022).

CONCLUSION AND RECOMMENDATIONS

The findings provide important insights into the validity and reliability of consumer-grade activity trackers. However, the fact that these devices have been tested only under specific conditions limits the generalizability of the results. In particular, measurements taken in controlled laboratory environments and in free-living settings require comparative consideration. Furthermore, studies on the validity of these devices across diverse demographic groups, such as women, men, children, adolescents, adults, and the elderly, are currently insufficient.

In order to address these deficiencies, further research is needed:

Conducting studies with larger samples in different age and gender groups,

Testing on clinical populations (e.g., individuals with chronic diseases)

Detailed examination of different physical activity intensities (light, moderate, vigorous),

Analyzing laboratory data with real-life scenarios,

It is recommended to focus on comparative validity studies across devices.

Comprehensive research in this direction will contribute to the more reliable and effective use of consumer-grade activity trackers in both physical activity monitoring and large-scale public health studies.

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CHAPTER 5

FUTURE ANXIETY IN PRE-SERVICE PHYSICAL EDUCATION TEACHERS: A COMPARATIVE STUDY BY GENDER AND YEARS OF STUDY

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Introduction

Future anxiety is defined as a state of awareness characterized by uncertainty, worry, and fear regarding potential threats to an individual's future happiness, security, and overall well-being (Zaleski, 1996). This type of anxiety reflects individuals' heightened sensitivity to possible future events and their perception of having limited control over what lies ahead. Individuals experiencing future anxiety often engage in persistent cognitive preoccupation with upcoming life circumstances, which may lead them to anticipate negative outcomes even in situations where objective risk is minimal. As a result, future anxiety becomes dominated by apprehension rather than constructive planning. It is emphasized in the literature that future anxiety encompasses a broad spectrum of negative possibilities, including fears related to future failure, unexpected accidents, health-related problems, financial instability, and other adverse life circumstances that may threaten personal goals and life satisfaction (Demir et al., 2023).

These concerns are not limited to a single life domain but rather extend across academic, professional, social, and personal areas. Consequently, individuals may experience persistent tension and emotional discomfort as they attempt to mentally prepare for multiple uncertain scenarios simultaneously. At the core of future anxiety lies individuals' inability to accurately predict future outcomes, their tendency to develop pessimistic expectations, and the lasting impact of previous negative experiences, all of which contribute to heightened feelings of uncertainty and helplessness (Molin, 1990). Past failures, disappointments, or traumatic events may reinforce beliefs that negative outcomes are inevitable, thereby strengthening anxiety-related thought patterns. These cognitive and emotional processes often lead individuals to overestimate potential risks while underestimating their own coping abilities, which further intensifies psychological distress and emotional vulnerability. Moreover, future anxiety may cause individuals to focus excessively on potential threats rather than opportunities, limiting their capacity for adaptive problem-solving and long-term goal setting. This excessive focus on risk can interfere with decision-making processes, reduce self-confidence, and diminish overall life satisfaction. Over time, these recurring patterns can create ongoing stress and slowly weaken a person's emotional resilience, making it harder to handle everyday challenges. The constant pressure can also increase the risk of developing mental health problems, such as depression or generalized anxiety. In addition, this strain may affect relationships, work performance, and overall quality of life, as individuals struggle to manage their emotions effectively.

The literature indicates that future anxiety does not arise solely from personal or psychological factors but is significantly influenced by broader economic, social, and cultural changes. Rapid transformations in labor markets, economic instability, rising unemployment rates, and shifting social structures intensify individuals' concerns about education, career prospects, financial security, and social status. In an increasingly competitive and unpredictable global environment, individuals may perceive the future as fragile and unstable, which further amplifies anxiety-related thoughts. Within the academic context, students experiencing high levels of future anxiety may encounter substantial difficulties in adapting to university life, maintaining academic motivation, and achieving educational goals (Korkmazer, 2020; Hammad, 2016; Rabei et al., 2020). Concerns about post-graduation employment, academic performance, and social expectations may impair concentration, reduce engagement in learning activities, and negatively affect overall academic success. Therefore, future anxiety represents a critical psychological construct that warrants attention, particularly among university students navigating transitional life periods characterized by uncertainty and change.

University students' undergraduate education period is widely regarded as one of the most critical and formative turning points in their lives, as it marks a significant transition from adolescence to adulthood as well as from formal education to professional life (Arnett, 2000). This developmental stage involves not only academic growth but also profound personal, social, and psychological changes. During this period, students are expected to make a series of important and often irreversible decisions that will shape their future trajectories. These decisions include choosing a career path, determining their roles and identities in both professional and social contexts, and developing long-term personal, academic, and occupational goals. As students attempt to define their sense of self and envision their future lives, they are often confronted with uncertainty and pressure arising from both internal expectations and external demands (Batool & Ghayas, 2020; Branje, 2022). It is frequently emphasized in the literature that students' levels of future anxiety tend to increase during the undergraduate years due to a wide range of interrelated factors. These factors include concerns about making appropriate career choices, fears regarding the ability to establish a stable and secure life, changes and disruptions in friendship networks, and uncertainty about maintaining social relationships after graduation. In addition, the fear of unemployment, economic instability, and the growing number of responsibilities associated with adulthood further contribute to heightened anxiety levels. As students approach graduation, these concerns often become more intense, as the protective structure of university life gradually gives way to the realities of the labor market and adult responsibilities (Bayar et al., 2022; Kula & Saraç, 2016).

Within this broader context of future anxiety, career-related concerns are consistently highlighted as one of the most central and influential sources of stress for university students. Career uncertainty not only affects students' academic motivation and decision-making processes but also has a direct impact on their overall psychological well-being. According to Kim (2003), career anxiety ranks first among the various sources of anxiety experienced during the university period, indicating that uncertainties related to employment opportunities, career advancement, and professional identity play a dominant role in shaping students' emotional experiences. The anticipation of entering a competitive job market and the lack of clear career prospects can lead to feelings of helplessness, self-doubt, and reduced self-efficacy. Supporting this perspective, the findings of a study conducted by Gizir (2005), which examined senior university students' levels of anxiety related to their professional careers, reveal that students commonly experience intense worry about finding a job after graduation. Many students also express concern about being unable to secure employment in a profession directly related to the field in which they received their education and practical training. This mismatch between educational background and employment opportunities often leads students to question the value of their academic efforts and the adequacy of their professional preparation. Consequently, this situation further intensifies students' concerns about the future and contributes to heightened levels of uncertainty, stress, and emotional strain, particularly during the final years of undergraduate education when students are expected to transition into the workforce and assume adult roles.

It is stated that future anxiety is also observed to a significant extent among pre-service teachers as university students (Yılmaz, 2019). Pre-service teachers often experience intense concerns related to their professional futures, as the teaching profession requires success in centralized examinations and appointment processes that involve high levels of competition and uncertainty. In a study examining pre-service teachers' views on future anxiety, Arı and Yılmaz (2015) found that the majority of pre-service teachers experienced anxiety about not being appointed after the centralized examination required to become teachers, felt worried about their future, and were unable to view the future with optimism.

These findings suggest that structural factors within the teacher appointment system play a critical role in shaping pre-service teachers' psychological well-being. Furthermore, the imbalance between the number of graduates from teacher education programs and the limited number of available teaching positions is emphasized as one of the most important sources of future anxiety among pre-service teachers. The fact that 24,009 pre-service teachers graduated from teacher education programs (MEB Personel, 2025), while the Ministry of National Education allocated only 190 positions for physical education teachers in the 2025 teacher appointment process, highlights the severity of employment-related concerns in this field. This significant disparity intensifies fears of unemployment, prolongs uncertainty regarding professional identity, and increases feelings of insecurity among pre-service teachers (Atalay, 2020; Atıf Göçer, 2024; MEB, 2025; Nartgün, 2008).

In a study conducted by Akgün et al. (2007), it was reported that pre-service teachers' levels of future anxiety varied significantly according to gender. Specifically, female pre-service teachers exhibited higher levels of anxiety about the future compared to their male counterparts. This finding suggests that gender-related social roles, societal expectations, and perceived barriers in career advancement may play a significant role in shaping how individuals experience concerns about their future. In other words, the pressures and expectations placed on women in both educational and professional contexts might contribute to heightened anxiety regarding their future prospects (Kamyab & Hoseinzadeh, 2023). Similarly, Aslan (2010), in a study that examined university students' levels of anxiety and hopelessness, found that female students reported higher levels of both anxiety and hopelessness compared to male students. This suggests that female students may be more susceptible to emotional distress when faced with uncertainties about their personal, academic, or professional future. These findings collectively highlight a potential gender disparity in emotional responses to future-related concerns, indicating that women may be more sensitive to the stressors associated with anticipating and planning for the future. In contrast to these findings, Atalay (2020) conducted a study focusing on the employability perceptions of students enrolled in schools of physical education and sports and found no significant differences between male and female students regarding their perceptions of employability. Moreover, the study indicated that these perceptions remained consistent across different years of study, suggesting that students' evaluations of their career opportunities are influenced more by structural factors within the labor market—such as demand for specific professions, employment trends, and available opportunities—than by individual demographic characteristics, including gender or year of study. This finding implies that, in some contexts, broader socioeconomic and structural conditions may play a more decisive role than personal or demographic factors in shaping students' outlook on their future employment prospects. Additionally, Büyüktopçu (2017), in a study exploring university students' anxiety toward the future, found that attitudes toward the future did not show significant differences based on gender. However, a notable difference emerged according to the year of study. Specifically, second-year students exhibited higher levels of anxiety toward the future compared to first-year students. This finding may be explained by the fact that as students' progress through their university education, they become increasingly aware of the academic, professional, and social expectations placed upon them. This heightened awareness may lead to intensified concerns and anxiety regarding the uncertainties and responsibilities associated with future academic and career paths. In other words, the progression through university may contribute to an increased recognition of the challenges and pressures of adult life, which in turn influences students' anxiety and emotional responses to their future.

It is widely recognized that young people's levels of future anxiety and their expectations about the future are shaped not only by personal characteristics and educational experiences but are also strongly influenced by the broader economic, social, political, and cultural context of their country. For instance, fluctuations in the labor market, shifting societal expectations, evolving educational policies, and the overall stability of the economy can all play a crucial role in determining how young people perceive their opportunities, plan for their careers, and imagine their long-term futures. These macro-level factors can interact with individual experiences, shaping both emotional responses and practical decision-making related to education, career, and personal development (Borgh et al., 2025). In line with this perspective, a study conducted by Atıf Göçer (2024) investigated pre-service teachers' experiences with the pressures associated with the KPSS (Public Personnel Selection Examination), including exam-related stress, interview anxiety, and uncertainties surrounding appointment to teaching positions. The study found that these stressors occupied a significant portion of pre-service teachers' cognitive and emotional resources, suggesting that the anticipation of bureaucratic processes and competitive examinations can have a profound impact on young individuals' mental well-being. Moreover, the research highlighted that the cumulative pressure of preparing for the KPSS examination, managing the stress of interviews, and coping with the uncertainty of appointment outcomes had far-reaching consequences not only psychologically but also economically and academically. Specifically, the study indicated that these stressors contributed to a noticeable decline in academic productivity, as students found it increasingly difficult to focus on their coursework and educational responsibilities. Additionally, pre-service teachers reported heightened feelings of hopelessness and future anxiety, which in turn negatively affected their motivation and engagement in both social and academic activities. This suggests that the intertwined pressures of high-stakes examinations, career uncertainty, and systemic expectations can create a complex web of challenges, influencing young people's emotional well-being, academic performance, and overall life satisfaction. Consequently, such findings underscore the importance of considering both individual and structural factors when evaluating young people's perceptions of their future and their capacity to cope with associated stressors.

Given these findings, it becomes evident that the future anxiety experienced by pre-service teachers, particularly those in physical education programs, is multifaceted and influenced by both structural and personal factors. Therefore, comparing the levels of future anxiety among pre-service physical education teachers according to gender and years of study is considered an important contribution to the literature. Such a comparison can provide deeper insights into how demographic variables intersect with educational and occupational stressors to shape students' anticipatory fears and expectations about their future professional lives. In this context, the primary aim of the present study is to examine and compare the future anxiety levels of pre-service physical education teachers with respect to their gender and years of study, thereby enhancing understanding of the factors contributing to future anxiety among pre-service physical education teachers.

Method

Research Model

This study was conducted using a correlational descriptive research design, which combines the objectives of both descriptive and correlational research. Descriptive research aims to provide a clear and accurate portrayal of the current situation by systematically observing and documenting characteristics, behaviors, or conditions without manipulating any variables. In contrast, correlational research seeks to examine the relationships between two or more variables to determine whether and how they are associated, without establishing

cause-and-effect relationships or controlling for external factors. By using a correlational descriptive design, this study not only describes the existing characteristics of the participants but also explores potential associations between key variables in their natural context. This approach allows researchers to gain insight into both the status and relationships of variables, providing a comprehensive understanding of the phenomenon under investigation while minimizing external influences (Fraenkel et al., 2012).

Participants

The study sample consisted of a total of 99 undergraduate students enrolled in the Department of Physical Education and Sports Teaching, including students from the 1st through the 4th years of their undergraduate education. Of these participants, 48 were female and 51 were male. The mean age of the female students was 20.23 years with a standard deviation of ±2.10, while the male students had a mean age of 20.55 years with a standard deviation of ±3.17. When considering the entire study group, the overall mean age of the participants was calculated as 20.39 years with a standard deviation of ±2.69.

Data Collection Instruments

The Demographic Information Form and the Dark Future Scale were used to collect data in the study.

Demographic Information Form

The Personal Information Form, which was prepared by the researchers, included questions about the age, gender and years of study of the physical education pre-service students.

Dark Future Scale

The Dark Future Scale used in this study was originally developed by Zaleski (1996) to assess individuals' anxiety and negative expectations regarding the future. The Turkish adaptation of the scale was carried out by Hatun and Demirci (2025), who examined its validity and reliability within a Turkish population. The scale has a unidimensional structure and consists of a total of five items designed to measure future anxiety. Each item is rated on a 7-point Likert-type scale ranging from "Definitely False (0)" to "Completely True (6)." Total scores obtained from the scale range between 0 and 6, with higher scores reflecting higher levels of anxiety and pessimism about the future. Regarding reliability, the original study reported a Cronbach's alpha coefficient of 0.84, indicating good internal consistency. In the present study, the internal consistency of the scale was recalculated, and the Cronbach's alpha reliability coefficient was found to be 0.88, demonstrating a high level of reliability for the current sample.

Data Collection Procedures

Prior to the implementation of the study, ethical approval was obtained from the relevant Institutional Ethics Committee to ensure compliance with ethical standards. Following the approval, permission was sought from the instructors responsible for the courses attended by the pre-service physical education teachers, and detailed information about the purpose and procedures of the study was provided to them. After obtaining the necessary permissions, the pre-service teachers were informed about the aim, scope, and procedures of the research. They were clearly informed that participation was voluntary, that they could withdraw from the study at any time without any negative consequences, and that all data collected would be used solely for scientific purposes and kept confidential. The scale was administered to the pre-service physical education teachers before the beginning of the

lesson at a time that did not interfere with the normal flow of the class. During the data collection process, participants were encouraged to respond to the scale items carefully and honestly, and any questions they had were addressed. The data collection procedure was completed in accordance with ethical principles and scientific research standards. During the data collection process, one of the researchers was present in the classroom to assist the participants and respond to any potential questions regarding the data collection instruments. This ensured that the participants clearly understood the items and the instructions. The completion of the data collection instruments required no more than 10 minutes.

Data Analysis

The researchers conducted a comprehensive analysis of the data obtained in the study by utilizing IBM SPSS Statistics version 27.00, a widely recognized software package for statistical evaluation. Initially, preliminary assessments were performed to examine the normality of the data distributions, and the results indicated that the data met the assumptions of normality, allowing for the application of parametric tests. For the purpose of statistical analysis, an independent samples t-test was employed to evaluate pair-wise comparisons between two groups, while a one-way analysis of variance (ANOVA) was conducted to assess differences among three or more groups. In addition to these inferential statistical tests, descriptive statistics were also calculated to provide a clear summary of the central tendencies, variability, and overall characteristics of the dataset.

Findings

The research findings revealed a difference between female and male pre-service physical education teachers in terms of future anxiety levels, $[t(97)= 2.492, p< .05]$. Specifically, female pre-service teachers ($\bar{x}_{female}= 3.35, SD= 1.55$) had higher levels of future anxiety compared to male pre-service physical education teachers ($\bar{x}_{male}= 2.55, SD= 1.62$). For a clearer visualization of these findings, the detailed statistical results of the analysis are presented in Table 1. The table illustrates the mean scores, standard deviations, and the t-test results, allowing for an immediate comparison between male and female participants.

Table 1. Comparison of Future Anxiety Levels of Pre-service Physical Education Teachers by Gender

Gender	n	$\bar{x}$	SD	t	P
Female	48	3.35	1.55		
				2.492	.01
Male	51	2.55	1.62		

A comparison of pre-service physical education teachers across their years of study indicated that their future anxiety levels did not vary significantly, ($F(3, 95)= 0.282, p> .05$). These results suggest that future anxiety levels were comparable across all years of study ($\bar{x}_{1st\ year}= 2.82, SD= 1.23$; $\bar{x}_{2nd\ year}= 2.88, SD= 1.69$; $\bar{x}_{3rd\ year}= 2.88, SD= 1.76$; $\bar{x}_{4th\ year}= 3.25, SD= 1.79$). The detailed results of the analysis are presented in Table 2.

Table 2. Comparison of Future Anxiety Levels of Pre-service Physical Education Teachers by Year of Study

Years of Study	N	$\bar{x}$	SD	F	p
1st Year	22	2.82	1.23		
2nd Year	23	2.88	1.69	.282	.83
3rd Year	35	2.88	1.76		
4th Year	19	3.25	1.79		

Discussion

The primary objective of this study was to examine and compare the levels of future anxiety among pre-service physical education teachers, taking into consideration both their gender and the number of years they had spent in their academic program. The analysis of the findings revealed a statistically significant difference in future anxiety levels based on gender, indicating that female pre-service physical education teachers experienced notably higher levels of future anxiety compared to their male counterparts. This suggests that gender may play an important role in shaping anticipatory concerns related to future professional and personal challenges. On the other hand, when future anxiety levels were examined across students from different years of study, ranging from the first to the fourth year, no statistically significant differences were observed. This indicates that the duration of study or the progression through the academic program did not appear to have a measurable impact on the future anxiety levels of pre-service physical education teachers, suggesting that other factors beyond years of study may contribute to variations in anxiety about the future.

In a study conducted with students enrolled in a school of physical education and sports, Atalay (2020) reported no significant difference between female and male university students in terms of their perceptions of employability after graduation, indicating that both groups held similar expectations regarding future employment opportunities. Likewise, Arı and Yılmaz (2015), who examined pre-service teachers' views on future anxiety, found that the majority of participants experienced anxiety related to not being appointed to a teaching position, expressed concerns about their future, and reported difficulty in maintaining a hopeful outlook. However, they also noted that these concerns did not differ significantly by gender. Similarly, Büyüktopçu (2017) found that university students' attitudes toward the future did not show a significant gender-based difference. These findings are not consistent with the results of the present study. Conversely, Akgün et al. (2007) found that pre-service teachers' future anxiety levels differed by gender, with female pre-service teachers reporting higher anxiety levels than their male counterparts. In line with these findings, Aslan (2010) determined that female university students experienced higher levels of anxiety and hopelessness compared to males. These results are consistent with the present study. Furthermore, Aslan (2010) emphasized that women face a higher risk of unemployment than men when youth unemployment rates are examined on a gender basis. Supporting this argument, data published by the Turkish Statistical Institute (2025) indicate that men's labor force participation rate is considerably higher than that of women. This structural inequality in labor force participation may contribute to female pre-service teachers' heightened concerns and uncertainties regarding their professional futures, thereby increasing their levels of future anxiety.

Regarding years of study level, the findings of the present study demonstrated that future anxiety levels of pre-service physical education teachers did not differ significantly across four (1st year, 2nd year, 3rd year, and 4th year) years of study. In contrast to this finding, Korkmazer (2020) found that university students' perceptions of unemployment anxiety varied according to their years of study. Similarly, Çakmak and Hevedanlı (2005) reported that university students' unemployment anxiety levels differed based on the year of study. In addition, Rabei et al. (2020) observed that students enrolled in nursing and education faculties experienced varying levels of future anxiety depending on their years of study, with senior students reporting higher anxiety levels related to their imminent transition into professional life. These findings do not align with the results of the present study. However, consistent with the current findings, Kaya and Varol (2004) reported that university students' future anxiety levels were similar across all years of study. Likewise, Büyüktopçu (2017) found that students from different years of study exhibited comparable future anxiety levels. It has been emphasized in the literature that challenges faced during the job-search process, intense competition in the labor market, ongoing changes in employment conditions, and economic uncertainties contribute to future anxiety among young people and negatively affect their mental health and overall quality of life (Türk & Işık, 2024). Based on this perspective, the similarity in future anxiety levels among pre-service physical education teachers across all years of study may be attributed to the perception that these unfavorable conditions will persist regardless of students' academic progression. Moreover, this situation may be explained by the fact that prevailing social, economic, and political problems affect students similarly, independent of their years of study (Yılmaz et al., 2004; Yüksel, 2003).

Conclusion and Recommendations

In conclusion, the findings of the present study demonstrate that female pre-service physical education teachers experience significantly higher levels of future anxiety when compared to their male counterparts. This difference suggests that female pre-service teachers are more likely to perceive their future as uncertain, unstable, and pessimistic, which may negatively affect their motivation and overall well-being during their training period. Such perceptions of uncertainty may stem from concerns related to employment prospects, social expectations, or perceived challenges within the profession.

Furthermore, the results indicate that the factors contributing to future anxiety among pre-service physical education teachers appear to exert a similar level of influence regardless of the year of study. This finding implies that future-related concerns persist throughout the undergraduate education process and are not limited to a specific academic stage. Consequently, pre-service teachers may carry these anxieties from the early years of their education through to graduation, highlighting the need for continuous support mechanisms throughout their academic journey.

In order to reduce and manage the future anxiety experienced by pre-service physical education teachers, the Ministry of National Education could develop and implement policies aimed at increasing employment opportunities within public institutions. Such policies may help alleviate concerns related to job security and career uncertainty, thereby contributing to a more optimistic outlook among pre-service teachers. Additionally, it is essential to examine in greater depth the underlying reasons for the higher levels of future anxiety observed among female pre-service physical education teachers. A comprehensive understanding of these

factors would enable the development of targeted interventions, support programs, and counseling services designed specifically to address the needs of female pre-service teachers.

Future research may also focus on investigating whether and how future anxiety levels among pre-service physical education teachers influence their professional development, teaching competencies, and long-term career commitment. Understanding this relationship may provide valuable insights into how anxiety impacts professional identity formation and performance in educational settings. Moreover, further studies employing qualitative and mixed research methods could offer a more detailed and nuanced understanding of the experiences, perceptions, and emotional challenges associated with future anxiety. Such approaches may help capture the complex nature of future anxiety among pre-service physical education teachers and contribute to the development of more effective preventive and supportive strategies.

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