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MEANING OF SPORT MONITORING AND ITS DEVELOPMENT TENDENCIES

Kārlis Vītoliņš

Andra Fernāte

Atis Kovaļovs
Latvian Academy of Sports Education, Latvia

Abstract. *The earliest research on analytics in sports dates back to 1912 with the work by Hugh Fullerton on the correlation between baseball player hits, throws, and catching techniques, and success in the game. Nowadays with equally high technological and financial availability, the efficiency of the training process becomes more relevant. A well-organized and managed training process, combined with high technology and financial accessibility, will be the determining factor for successful performance. Research aim: to compare and analyse the meaning of sport monitoring and its development tendencies. Research methods: a systematic review of scientific literature was conducted, examining scientific articles available in the ScienceDirect and Google Scholar electronic databases (publishing date 2014-2024) using the following keywords: "monitoring", "sport monitoring", "performance monitoring", and "coaching monitoring". As a result of the study, the use of the term 'monitoring' in the context of the sport environment was clarified. The meaning and function of monitoring involves continuous systematic data collection based on selected criteria, with its most essential function being the ability to instantly inform involved parties about the characteristics of the performance process. Monitoring in sports is primarily applied in terms of athlete and team performance analytics. However, it is equally important to continuously and systematically observe the activities of coaches with the aim of providing feedback for improvement.*
Keywords: *coaching monitoring, monitoring in sports, performance monitoring, sport monitoring.*

Introduction

The earliest study on sport performance analytics is considered to be the study by Hugh Fullerton in 1912 on the correlation between baseball players pitching, hitting, and catching techniques and their success in the game (Hughes & Franks, 2004). Performance analytics, or technically, the quantification of tactical actions, is widely spread in the field of sports, particularly in football, where the high level of development has led to extensive use of performance monitoring tools in the training processes.

The monitoring of sport training processes has been examined in the publication by Roy et al. (2018), concluding that internal and external training loads are measured and quantified in the process of sport performance monitoring.

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While studying the process of monitoring training loads in elite-level English football, Weston (2018) indicates that the implementation of the monitoring process is not significantly expensive or time-consuming, citing the introduction of the "rated perceived exertion - RPE" scale for players' self-assessment of training load difficulty as an example. Effective monitoring of training loads and the ability to immediately adjust the training process are significant factors in achieving success in the field of sports.

Studies on the periodization systems of multi-year (macrocycle) training processes have been criticized for their validity and the lack of consideration of complicating reliability factors (Afonso et al., 2017). If control and supervision methods, or the opportunity to receive feedback, are not included in the periodization system, then its effectiveness is difficult to explain.

Another significant factor is insights from studies on the importance, content, and effectiveness of feedback in improving the quality of the learning process (Otte et al., 2020). The relevance, effectiveness, and timeliness of feedback are crucial for improving athlete performance. Unfortunately, the study by Cook & Dorsch (2014) indicates that negative, potentially abusive behaviour by coaches towards athletes is often encountered in the sport environment. Self-reflection and the ability to observe one's own performance from an outside perspective to prevent unwanted behaviour and problematic situations, and to optimize performance are emphasized as more essential skills for expert-level educators (Schempp et al., 2006; Webster & Schempp, 2008).

Authors Mallett & Côté (2006) note that the process of evaluating the actions of a coach has been under-researched. The most commonly mentioned aspect of evaluating coaches by authors is the win/loss ratio, which, in turn, does not reflect the broad and multidimensional framework of coaches' activities. Alongside the equally high relevance of technology and financial accessibility, the enhancement of training process effectiveness is regained. Nowadays, the equally high development of technology and financial accessibility has become a precondition for the effectiveness of the training process. A well-organized and managed training process with the use of high technology and financial investment is considered a decisive factor for successful performance (Sands et al., 2017). Identifying and evaluating successful performance factors in multi-year training processes is a fundamental prerequisite for ensuring successful performance. Therefore, the aim of this study is to compare and analyse the meaning of sport monitoring and its development tendencies.

Research methodology

To research the essence of sport monitoring and its development trends, a systematic search and review (Booth, Sutton & Papaioannou, 2016) were conducted in two electronic databases of scientific literature: ScienceDirect (SD)

and Google Scholar (GS). Studies that met the following eligibility criteria were included for further screening: 1) were published in English, 2) were available in the electronic databases Google Scholar or ScienceDirect, 3) published from 2014 to 2024, 4) focused on the meaning of sports monitoring and its development tendencies. The keywords "monitoring", "sport monitoring", "performance monitoring", and "coaching monitoring" were used in the aforementioned language. Studies published from 2014 to 2024 were examined, and those that included the keywords in the title, abstract, or keywords were considered. The search process was repeated 3 times, resulting in the selection and in-depth examination of 10 studies.

Research results

The study examined scientific articles available in English in the electronic scientific databases (SD) and (GS). Entering the same keywords, more articles were found in the ScienceDirect database. The highest number of publications was found when entering the keyword "monitoring" (n=397 100), followed by the more commonly used keywords "performance monitoring" (n=50 390), "sport monitoring" (n=932), and "coaching monitoring" (n=346) see in Figure 1.

It can be observed that the most frequently used term is "monitoring", which can be explained by its frequent use in a wide range of fields. When narrowing down the search range and adding the words "performance", "sport" and “coaching”, it is noticeable that the number of found articles decreases significantly.

Evidently, sport performance analytics is frequently discussed and described in scientific articles. However, the least number of articles and significant difference from other keywords is in the frequency of use of the term "coaching monitoring". The term "monitoring" is rarely used in articles related to coaching activities, as indicated by Mallett & Côté (2006), stating that the evaluation and supervision of coaches' actions are seldom discussed.

Upon reviewing the studies, 10 articles published in the last decade were identified, which reveal the essence and development tendencies of monitoring in relation to sports. These articles were thoroughly examined to identify and compare the essence and development tendencies of sport monitoring in various publications.

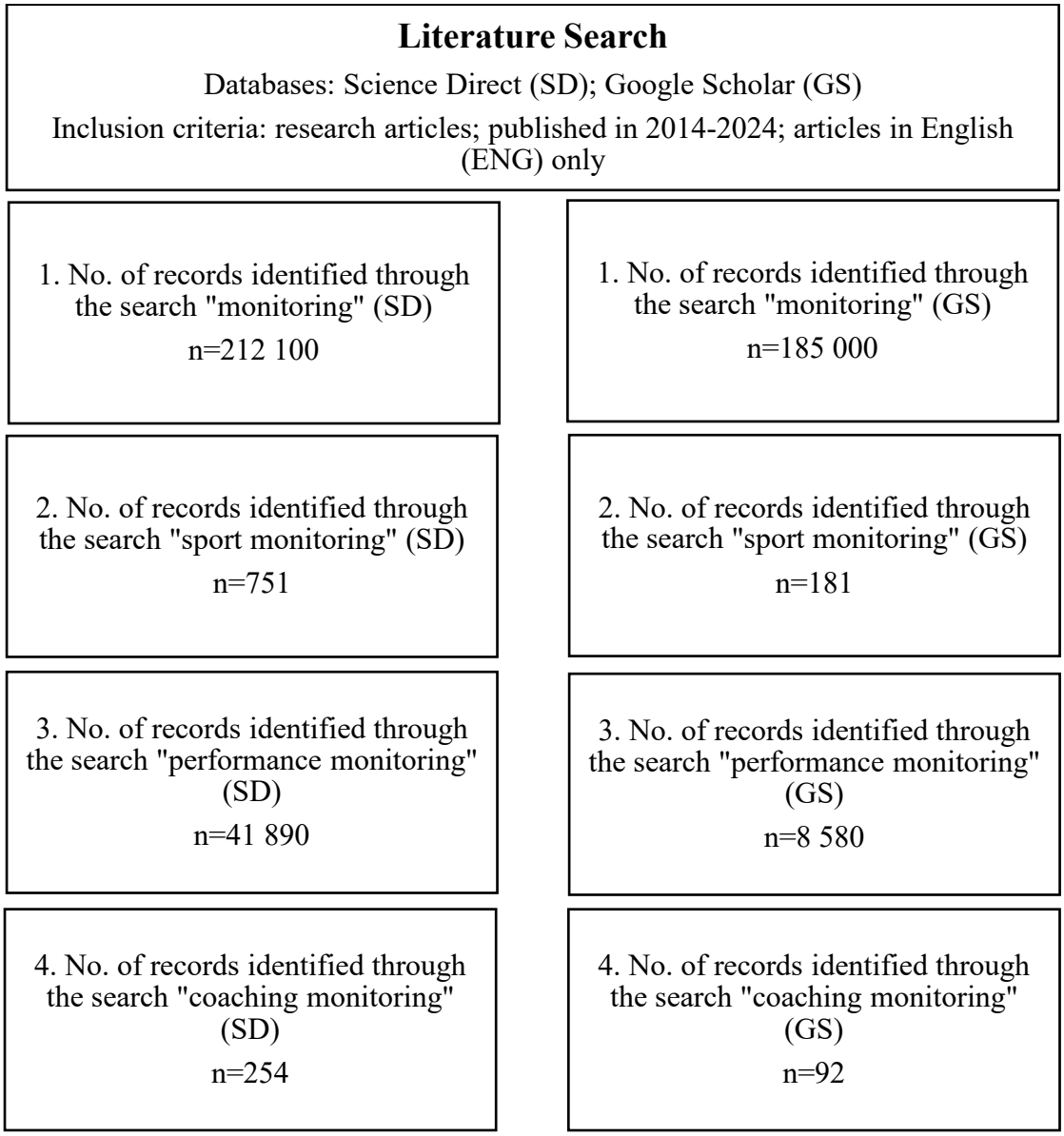

Figure 1 ***The Process of Systematic Search*** *(by the Authors)*

In the first selected article (Frost et al., 2023), it is indicated that implementing a tool for monitoring the mental state of elite-level coaches would help identify elevated stress levels early and prevent the development of illnesses. The essence of monitoring was described as a "tool that identifies early" and "allows intervention". While studying the use of POLAR M400 sports watches in team sports games, authors (Makar et al., 2023) point out the essence of monitoring in the field of quantifying the training process. The data obtained with the heart rate monitor help to obtain quantitative indicators to assess the impact of the training process on player performance.

Table 1 ***The Essence of Sport Monitoring and Development Tendencies Explained in the Reviewed Publications*** *(by the Authors)*

Author/s, Year	**The Meaning of Sport Monitoring and Development Tendencies**	**Selected Monitoring System Components**
(Frost et al., 2023)	"Academics and representatives of the sports industry would benefit from a tool that identifies signs of psychological stress and mental illness among elite-level coaches. Such a tool would help identify early and intervene before the development of mental illness or the onset of a mental crisis."	*Tool that identifies signs* *Identify early* *Intervene before*
(Makar et al., 2023)	One of the main reasons for movement demand monitoring is to quantify and select the training process's impact results on player performance...	*To quantify* *Impact results on performance*
(Miles et al., 2019)	"… the majority of the sleep monitoring conducted is through self-reported sleep diaries, with minimal use of validated questionnaires or objective assessments. Limited objective sleep monitoring is not unsurprising, as there can be difficulties accessing required equipment, users need specific skills to ensure effective use, and it can be impractical when trying to implement with large groups of athletes."	*Self-reported diaries* *Limited Objective assessment* *Specific skills* *Impractical with large groups of athletes*
(Youssef et al., 2023)	"In this work, we develop techniques based on learning models to draw conclusions about exercise recognition and identification, forecasting subject biometrics, exercise assessment, and simultaneous recognition and assessment."	*To draw conclusions* *Recognition and identification* *Forecasting subject biometrics*
(Chang et al., 2017)	"The results of this study indicate that main coaches and fitness trainers need to be encouraged to monitor athletes' stress levels during training in order to maximize the benefits of the training process."	*To maximize the benefits of the training process*
(Essaoudi et al., 2015)	"This cross-sectional, descriptive and qualitative research had a threefold purpose: 1) to identify and describe different effective professional tasks and duties of the "expert" inspector of education; 2) contribute to the development of a competency framework of the inspector; 3) deduce the real training needs of inspectors."	*Identify and describe* *Contribute to development* *Deduce needs*
(Malone et al., 2018)	"The results suggest that systematic monitoring of player well-being within soccer cohorts can provide coaches with information about the training output that can be expected from individual players during a training session."	*Provide with information about the training output*

Author/s, Year	**The Meaning of Sport Monitoring and Development Tendencies**	**Selected Monitoring System Components**
(Albert & Arnrich, 2024)	"This paper proposes a computer vision method to continuously monitor fatigue during resistance training by predicting external and internal parameters, namely the generated power and the rating of perceived exertion."	*Continuously predicting external and internal parameters*
(Fasey et al., 2022)	"A continual awareness, evaluation and monitoring of a range of concurrent changes was therefore central to the ability of an organization to successfully and sustainably deal with those changes." "Interpretation and evaluation of information is not a linear, temporal response to significant change, but instead is continuous and iterative, also acting as a form of feedback to evaluate and monitor the outcomes of actions taken in anticipation of or in response to significant change." "Given the ongoing and iterative nature of significant organizational changes, these processes are not sequential or temporally distinct, but instead cumulatively contribute towards the capability of an organization to deal successfully with the multiplicity of changes faced at any one time."	*Continual awareness to deal with changes* *Continuous and iterative form of feedback* *Cumulatively contribute to deal with the multiplicity of changes*
(Guo et al., 2020)	"In this work, we propose FitCoach, an integrated mobile solution that can conduct systematic fitness monitoring and provide performance review based on a single off-the-shelf wearable device (e.g., wrist-worn wearables or arm-mounted smartphones)."	*Systematic performance review*

One significant influencing factor on the performance of athletes in team sports games is the quality of the recovery process, and one of the most important ways for athletes to recover is during sleep (Miles et al., 2019). Author Kathleen Miles indicates that adhering to selected "criteria" is essential for sleep monitoring, and athletes often struggle with self-reflection on the quality of their sleep. The lack of knowledge about sleep quality is identified as a problem, and the introduction of a monitoring tool can be particularly effective in working with team sports athletes.

Several publications that were examined in-depth (Essaoudi et al., 2015; Albert & Arnrich, 2024; Fasey et al., 2022) provide a consistent explanation of the essence of monitoring as a "continuous and iterative process". This can be

explained by the essence of monitoring as a continuous systematic process of performance observation, accumulating data based on selected criteria.

The selected articles on the essence and functions of monitoring in the field of sports indicate the essence of monitoring as a continuous systematic data collection process, helping involved parties to make fact-based decisions promptly and to document changes over time to forecast further development dynamics.

Discussion and conclusions

In the conducted study, examining scientific articles published in the last decade allowed to observe that the term "monitoring" is often used in publications related to management processes in the sport environment. In the rapidly evolving modern sport environment, with equally accessible information and financial resources, the effectiveness of the training process and its compliance with specific environmental conditions are considered significant. This directly explains the broad significance of the term "monitoring" in the field of sport performance analytics.

Sport monitoring is primarily examined in relation to athlete and team performance analytics. Monitoring in sports is most commonly used for athlete performance analytics, monitoring the effects of training on physical performance, and predicting trends in the development dynamics. Equally important is the continuous and systematic observation of the actions of the coaches to provide necessary feedback on the development directions and to assist coaches and stakeholders in effective, good coaching practices. The study results are similar to previous research conclusions that coaching evaluation is under research (Mallett & Côté, 2006). Our study is also in line with research and supports further research in coaching monitoring (Sands et al., 2017), because well-organised and managed training process with effective timeliness feedback is crucial for improving athlete performance over time.

The essence and functions of sport monitoring were examined in selected studies published in the last decade and available in the electronic databases Science Direct and Google Scholar. The unifying description of the essence of sport monitoring in the selected publications is that its essence lies in continuous systematic monitoring, using specific criteria in the management process which can contribute to the decision-making process for involved stakeholders.

The functions of sport monitoring include quantifying actions, cumulative data collection to provide immediate feedback for making necessary corrections, or monitoring the degree of achievement of a set performance criteria. To further promote overall improvements in sport performance, it would be essential to focus on monitoring coaches' actions.

The existing study has shown that while determining factors influencing athlete performance and action monitoring have been extensively studied, less attention has been paid to monitoring coaches' actions. Similarly, the inclusion of studies in scientific literature on the importance of expert-level sports coaches' self-reflection skills, the type and timeliness of feedback, and the often observed negative, potentially abusive behaviour of coaches, confirms the significant need for further development of sports coaches' action monitoring systems to provide coaches with immediate and precise feedback on their actions.

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