Enhancing Exercise Performance in Gyms: Applications of Sensor-Based Artificial Intelligence for Adult Males

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March 10, 2025

I Introduction

Artificial Intelligence (AI) is evolving rapidly, allowing people to automate certain tasks that could never have been imagined to be automated before. Indeed, AI offers advanced analytical capabilities, enabling the detection of behavioral patterns that are challenging for conventional data analysts to identify [1]. In particular, AI is widely used to make data-driven decisions [2], analyze complex information [3], and improve the efficiency of information search [4]. This review examines AI applications in sports, where technology-driven performance optimization directly impacts health and athletic outcomes. Specifically, it addresses the question: How may sensor-based Artificial Intelligence impact exercise performance of adult males aged 18-40 in gym?

II Method

A. Search strategy

For this Literature Review, the ScienceDirect database was selected due to its extensive repository of peer-reviewed articles. To be precise, more than 20 million articles and book chapters from over 2,800 peer-reviewed journals. Furthermore, ScienceDirect supports Boolean operators in search strings, providing consistent results on each request.

The "AI", "sports", "tracker", "sensor", "pose", "recognition", and "motion" keywords were chosen. Since the research question is closely connected to the application of AI in gyms. In total, two search strings were composed:

1. (ARTIFICIAL INTELLIGENCE OR MACHINE LEARNING OR TRACKER OR SENSOR) AND (SPORTS OR SPORT));
2. ("ARTIFICIAL INTELLIGENCE" OR "MACHINE LEARNING") AND (POSTURE OR POSE OR MOTION) AND (RECOGNITION) AND (SPORTS OR SPORT).

Initially, the strings contained only "AI", "ML", and "sports" keywords. This choice provided low relevance to the research question. Later, the keywords "sensors", "trackers" and "posture", "recognition" were introduced. The proportion of relevant articles increased

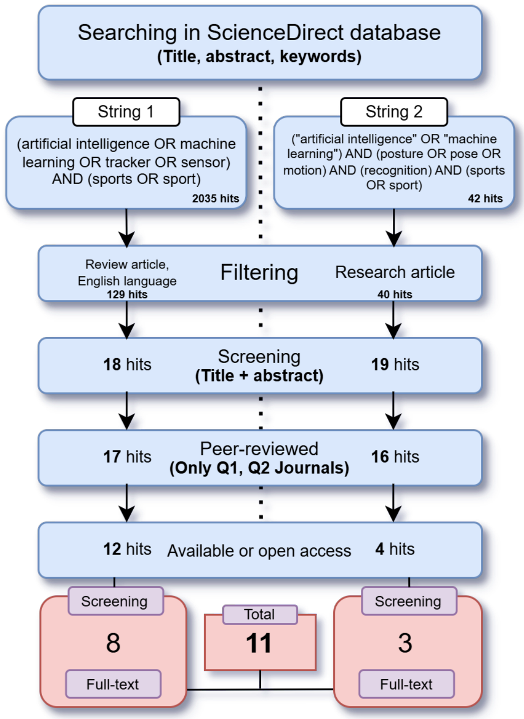

Fig. 1. Flowchart of search procedure.

due to the inclusion of sensor-based AI and image/video recognition systems. Hence, the first search string hits increased from 442 to 2035, but the second search string hits were reduced to 42 due to less research in the field of posture recognition in sports (Fig. 1). The strings were entered into "Title, abstract or author-specified keywords" field. For the first search string, filters "Review Article" and "English language" were enabled to review the information about existing sensors. The second search string was filtered using "Research Article" filter to focus on studies that provide specific and measurable results about how AI and motion/pose recognition are used or could be used in gyms. I considered only peer-reviewed articles to ensure the accuracy and reliability of the studies, as well as open-access articles due to limited access to paid resources as a student.

B. Data preparation

The initial step involved downloading the filtered articles and importing them into the Zotero reference management tool. No duplicate entries were identified in the dataset, thus manual removal of duplicates was not required.

C. Screening

The article screening consisted of two parts: Title + Abstract screening and Full-text screening. I removed irrelevant articles from the dataset if they were not related with AI, sports, fitness, weight training, sensors, Internet of Things (IoT), and motion or posture recognition. With the first screening, I excluded 111 studies from the first search string and 21 studies from the second search string. The last screening allowed me to narrow the first search by 33% and the second search by just one article (Fig. 1). In total, 11 articles were selected and transferred into the reading log. I read each publication and extracted main points to present and discuss in the section below

III Results

Strain sensors were used to address the issue of inaccurate detection of muscle activities during cardio [5]. As stated in [6], these sensors differed in designs and materials depending on the exercise requirements. In summary, strain sensors analyzed the load of cardio exercises and bending angle of muscles to provide feedback for user to perform exercises better.

AI image recognition models are an effective choice to evaluate actions that currently occur in gyms [7]. While [8], [9] focused on Human-Object Interaction (HOI) models and their applications, [10] discussed many Human Action Recognition (HAR) models and their accuracy. Both types of models could determine what the user was doing. Image recognition could be used in posture analysis [11], [8], gait analysis [11], [9], sport analysis [11], [8], [9], [10], injury prevention, remote physical activity tracking and ergonomics [11]. In addition to these methods, [10] suggested the possible use of HAR in pedestrian detection, human-computer interaction, video games, and surveillance. In conclusion, HOI models could be integrated in gyms to benefit both exercise performance and user health by reviewing a person's training technique, analyzing it, providing feedback on the accuracy of the exercise and pointing out severe errors.

Wearable devices are arguably the best choice to enhance safety and health of a user through real-time biometric monitoring and determine one's endurance limits to train more efficiently by enabling precise, individualized data collection. In support of this perspective, Reena et al. [12] reviewed possible parameters that could be extracted from wearables. For example, wearables could measure a person's velocity, body pressure, heart rate, and angle of inclination. These metrics, as stated in [13] and [7], enabled wearables to predict injuries, maximize user performance, and motivate wearers to stay healthy and increase overall activity. As highlighted in [13] and [14], various wearable devices include optical displays, smartwatches, electronic shoes, electronic socks, hearing aids, tattoos, subcutaneous sensors, and even smart clothes. In fact, wearables allow AI to access and analyze metrics that are impossible to obtain externally via cameras or exercise sensors. Thus, AI could account for the person's condition and provide feedback on one's health too.

Personal trainers are important to analyze human demands to compose the correct training plans. Both [14] and [7] agreed that AI could generate safe and effective training plans targeting various aspects of performance as well as automate individual monitoring. In fact, replacing human trainers with AI models could positively affect performance by negating human error and by analyzing similar people's physics.

TABLE I
Risk of Bias in Sources

Source	Bias description	Bias severity
[5]	Selection bias. This is a literature review without clear methodology on obtaining cited resources	High
[6]	Selection bias. This is a literature review without clear methodology on obtaining references for materials for wearables or design variants	High
[7]	Selection bias. This is a literature review without clear methodology on obtaining the cited articles	High
[8]	Selection bias. Only MSR Daily Activity 3D dataset was used to evaluate the performance of the model	Medium
[9]	Small sample size with decent (87.5%) recognition accuracy containing only 8 classes of actions from MPII Human Pose dataset	High
[10]	Selection bias. Authors used UT-Interaction, Hollywood, IXMAS, and UCF Sports public datasets without explanation of why exactly the researchers picked them	Medium
[11]	Selection bias. This is a literature review without clear methodology on obtaining the cited articles	High
[12]	Selection bias. A quality assessment was not done and crucial validation studies were ignored	High

[13]	Selection bias. This is a literature review without clear methodology on obtaining the cited articles	High
[14]	Selection bias. This is a literature review without clear methodology on obtaining the cited articles	High
[15]	Selection bias. Only one person among four conducted selection and screening of cited articles and the review exclusively focused on physiological parameters of the smart shirts	Medium

Table (I) describes risk and severity of bias of referenced sources. Most sources exhibit selection bias with just one exception of small sample size [9]. Overall, each referenced article has a severe risk of bias.

IV Discussion

A. Summary

The reviewed studies demonstrated that sensor-based AI applications enhanced exercise performance through three key mechanisms. Firstly, strain sensors enabled precise monitoring of muscle activity and biomechanical load during cardio, providing real-time feedback to optimize technique. Secondly, AI-driven image recognition models analyzed posture, gait, and exercise accuracy, supporting injury prevention and performance refinement. Finally, wearable devices collected individualized biometric data, such as heart rate and movement kinematics, to tailor training intensity and predict endurance limits. These technologies collectively facilitated data-driven training adjustments, reduced reliance on human trainers, and improved safety through continuous physiological monitoring.

B. Similar LRs

Burnie et al. [16] partially discussed the usage of pressure sensors in sports to improve gait training and assess foot function during walking and training. In contrast, this review exclusively mentions strain sensors and wearable sensors. However, integration of pressure sensor metrics with AI could improve performance of adult males even more by enhancing the AI with relevant information. In contrast to my review, Rosa [17] concludes, that integration of AI in sports could benefit disabled people by creating and managing training programs, accessible sport strategies, identifying barriers, and monitoring one's training progress.

C. *Implications*

The main application of the results lies in the creation of a smart gym with (1) automatic exercise detection, (2) exercise technique validation via sensors and HOI recognition, (3) AI trainers, and (4) development of personalized training plans based on gathered user data. The review could be improved by considering non-English and paid/closed access articles. Moreover, the review could consider pressure sensors to discuss their applications

D. *Limitations*

Cited articles: The results of this review are probably affected by biases of cited articles. In fact, all cited sources contain severe biases. Six reviews could be improved by providing and explaining the methodology to gain reproducibility and trust [5], [6], [7], [11], [13], [14]. Additionally, [9] should extend sample size to at least 24 discrete human action classes by adopting additional datasets, as well as [8]. Furthermore, Olsen et al. [12] have to perform quality assessment to validate the truthfulness of their results. Finally, [10] should provide an explanation for picking the datasets and [15] should oblige more people to independently screen and review selected articles.

LR limitations: Although the methodology of this review was clear, approximately 51% of the paid/closed access articles were excluded prior to the final screening. This exclusion potentially affected the review results by limiting the diversity of perspectives by half. Furthermore, another limitation is the language barrier problem. The results obtained from the first search string were filtered by the English language, removing ten possibly relevant studies. The last limitation is the exclusion of several types of sensors. In fact, only biological and image/video sensors were considered in integration with AI. However, the literature review could be extended to cover equipment-based sensors.

E. Acknowledgments

This literature review was supervised by Georgy Gelvanovsky and reviewed by peer students of Innopolis University.

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