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Review on Pedometers in the Era of Intelligence

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Abstract: *While intelligent technology facilitates people's lives, it also causes more office workers or students to sit at their desks for long periods of time, leading to health concerns. Compared to other group sports or sports that require professional equipment, running is the simplest, most efficient, and easy to implement. For professional track and field athletes or amateur running enthusiasts, a precise pedometer is a basic equipment configuration. The number of steps can indirectly reflect the exercise volume and speed of the exerciser, providing good data support for more scientific and reasonable fitness exercises. The purpose of this review paper is to sort out the current research status of pedometers and provide theoretical support for the interdisciplinary research of sports science, behavioral science, and computer science. In addition, this article analyzes the step counting data analysis and its application value in the era of large language models.*

Keywords: *Running; Walking; Step Counter; Pedometer; Sport*

1. Introduction

Running, as one of the most basic and ancient forms of human movement, has become the most popular national fitness activity worldwide due to its low cost, high convenience, and significant health benefits [1]. In college sports, running is not only an important teaching method to enhance students' physical fitness and cultivate their willpower, but also a key link in creating campus sports culture and implementing the "health first" educational concept. According to different speeds, it can usually be divided into fast running, slow running or jogging, and walking. For professional athletes, they usually try to run quickly for long periods of time. Ordinary sports enthusiasts will try jogging to achieve a fitness effect. Middle aged and elderly people usually choose walking as a form of exercise due to poor knees. In the fields of medicine or physical activity, it is commonly said that walking ten thousand steps a day is very beneficial [2]. This viewpoint was first proposed by Hippocrates and has been illustrated and validated in many literature [3,4].

However, the effectiveness of running exercise largely depends on the quantitative management and scientific guidance of exercise. The traditional experiential and fuzzy training mode is no longer able to meet the personalized and precise physical education needs of contemporary college students. The pedometer, as a portable electronic device designed to quantify human steps, has undergone a profound transformation from mechanical and electronic to intelligent in its development process. Early pedometers had a single function and could only achieve basic step counting. With the rapid development and integration of technologies such as MEMS, accelerometer and gyroscope, global positioning systems (GPS), and low-power Bluetooth, the functions of modern smart pedometers (usually carried by smartphone applications or smart bracelets/watches) are far from limited. They can accurately monitor and record various refined exercise data such as running distance, pace, trajectory, heart rate, step frequency, stride length, and even vertical amplitude. Therefore, this article aims to systematically review and summarize the research on running monitoring technology and its applications based on intelligent pedometers. Firstly, the benefits of running or walking were analyzed. Then, we provide an overview of the principles and research literature of various sports pedometers or step counters. Finally, the paper analyzed the running data analysis methods and future trends in the era of large language models and artificial intelligence.

2. The benefits of running or walking

Running has become the first choice for most people due to its relatively low technical threshold. Long term adherence to running or slow walking has the following benefits:

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(1) Eyes. With the rise of short videos, people of all ages will invest a lot of time in watching videos that interest them. These will undoubtedly harm people's eyes, especially children. People who persist in long-distance running spend about an hour every day looking straight into the distance, which is a good way to relax and rest their eyes. If you have school-age children at home who can keep running every day, the chance of myopia will definitely be reduced [5]. For people who need to work in front of a computer for a long time, it is also a good way to relieve eye fatigue.

(2) Internal organs. Persisting in running will give you a strong heart and cardiovascular system function. At the same time as increasing the maximum oxygen uptake, the amount of oxygen delivered to various organs in the body is greatly increased, and the working quality of each organ is naturally greatly improved. In addition, long-distance running can accelerate blood circulation, allowing the coronary arteries to have sufficient blood supply to the myocardium, thereby preventing various heart diseases [6]. By exercising the lower limbs, it promotes venous blood flow back to the heart and prevents the formation of venous thrombosis. In addition, running activity can improve and eliminate fatty liver [7].

(3) Blood. With a strong cardiovascular system, runners have better blood quality than ordinary people. The body's adaptability to long-term running can improve metabolism[8], reduce blood lipids and cholesterol levels [9].

(4) Lungs and respiratory system. Long term middle and long-distance running exercise strengthens lung function and increases lung capacity. Regular long-term long-distance running can develop the respiratory muscles of the lungs, increase the volume of each breath, and enhance lung function [10].

(5) Whole body muscles. Long term middle and long distance running can enhance respiratory muscles, heart muscles, neck muscles, chest muscles, arm muscles, as well as muscles in the waist, buttocks, thighs, calves, feet, etc., making it difficult for metabolites such as lactic acid or carbon dioxide to accumulate in various muscles[11]. Running can be said to be the foundation of all sports and will have a positive impact on your participation in other sports.

(6) Psychological or emotional regulation. Running not only promotes metabolism and blood circulation in the body, but also stimulates the secretion of substances such as endorphins and dopamine, making people feel happy and relaxed, reducing anxiety and stress. By persisting in running exercise, people can feel that their physical condition and health have improved, which can increase their confidence and sense of control, relieve anxiety and stress. During running, it is necessary to concentrate, control breathing and rhythm, which helps to distract attention, reduce focus on stress and anxiety, and to some extent alleviate feelings of stress and anxiety [12].

Scientific and reasonable jogging can promote people's health and even longevity. Insufficient exercise cannot achieve the desired effect, while excessive exercise can cause damage to the body. The latest research shows that taking 6000 to 8000 steps per day is the most appropriate, as exceeding it may lead to symptoms such as knee arthritis [13,14]. Therefore, in the process of running or jogging, reasonable control of exercise time, running distance, step frequency or speed and other indicators will be beneficial to the health of exercisers.

3. Types of Pedometers

The function of a pedometer is mainly reflected in quantifying data such as steps, distance, time, speed, etc., calculating the calories and calories burned during exercise, and also adding some fun to exercising people. Eight years ago, a review paper mentioned many types of pedometers, covering almost all categories [15]. The article also explained the significance of step count statistics and applications related to health. So far, there are various types of pedometers, which can be worn on the wrist, waist, legs, ankles, feet, pockets, and knees according to the wearing area. However, most sensors use acceleration sensors, which essentially measure the physical characteristics of human walking [16].

3.1. Sports Wristband or Watch

Due to convenience during exercise, the wearable devices widely used in the market are mainly wristband style. In fact, many sports wristbands now have functions that are not limited to step counting tasks, but can also be used for trajectory drawing [17], sleep monitoring [18], and heart rate measurement [19]. Usually, wristbands or watches that can be worn on the wrist have functional differences, with the latter having richer functions and higher prices [20]. Table 1 lists well-known wristband manufacturers

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and product features both domestically and internationally.

Table 1: Comparison of products and functions of well-known wristband companies.

Company	Product Model	Main functions
Xiaomi	Xiaomi Band 9 Pro, Xiaomi Band 10	Igniting the market with extremely high cost-effectiveness. Provide accurate step counting, heart rate sleep monitoring and other core functions, with good system compatibility. Positioning as entry-level and mass market.
Huawei	Huawei Band 9, Watch GT 4 Series, Watch Ultimate, Watch Fit Series	Having self-developed TruSeen ™ Heart rate monitoring technology has powerful health functions, such as arrhythmia screening and vascular health research. Long battery life and exquisite craftsmanship are its highlights. Positioning as an all-around health partner.
Codoon	Codoon Watch S2/S1, Bracelet, Running Watch X3	Strong reliance on the Codoon App ecosystem, providing professional running course guidance, real-time voice coaching, sports community challenges, and other functions. Targeting beginners in running and sports social enthusiasts.
Apple	Apple Watch Series 9/SE/Ultra 2	Deeply integrated into the iOS ecosystem, providing precise activity tracking, comprehensive health monitoring (ECG, blood oxygen), and powerful exercise modes. Positioning as a high-end smartwatch.
Fitbit	Charge 6, Versa 4, Sense 2, Inspire 3	A pioneer in the field of health tracking, renowned for its precise step counting, heart rate monitoring, and excellent sleep analysis. Having an active social community. Positioning a healthy lifestyle.
Garmin	Forerunner , Venu , Fenix , Vivosmart/vivosmart	Professional sports GPS watch leader. Provide extremely detailed exercise data and physiological indicators, such as training load, recovery time, pulse oximetry, etc. Targeting professional athletes and outdoor enthusiasts.

Explanation: The data for this survey is as of November 2025.

In addition, there are also ankle worn pedometers on the market, such as StepWatch [21]. The StepWatch instrument has been demonstrated through clinical validation to yield highly accurate step count data, including in populations with slow or irregular gait patterns.

Many scholars study the step counting accuracy performance of different devices, but the differences mainly depend on the comprehensiveness of the algorithm considerations [22]. In fact, most devices have high accuracy within the user's normal running range. If the user walks slowly, with small or irregular arm swings, there will be significant differences in the results.

3.2. Sports App for Smartphones

With the abundance of smartphone sensors, sensor based motion related applications are gradually increasing. These apps mainly use the built-in accelerometer on mobile phones for step counting, and can be divided into categories such as independent step counting apps [23], health platform apps [24], and sports social apps [25]. Table 2 shows the different types of step counting apps installed in smartphones. In order to achieve more diversified development, many apps tend to focus on social networking or add the function of exercise steps to social software [26].

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Table 2: Different types of step counting apps.

Application Name	Operating System	Main functions
Google Fit	Android	Automatically record steps, walking and running distance, and set a "heart score" goal. High integration with Android system.
Apple Health	iOS	Automatically record steps, walking and running distance, and floors climbed in the background. It is a centralized storage center for iPhone data.
Samsung Health	Samsung One UI 8 Android	Automatic step counting, providing detailed daily, weekly, and monthly trend analysis of step counts.
Strava	Android/iOS	Step counting is not a core function, but rather focuses on recording the movement trajectory, speed, and rank of cycling and running through GPS. A powerful sports social network, exploring popular routes worldwide, and competing with friends for specific ranks.
Huawei Health	Harmony OS	Accurately record steps, provide long-term trend analysis and personalized step target recommendations.
Keep	Android/iOS	Automatically record daily steps and exchange them for "burned calories" to be included in the total goal.
WeChat Sports	WeChat Mini Program Android/iOS	Connecting step data from mobile phones or wristbands to achieve friend step ranking, support likes and interactions.

In fact, thanks to the software and hardware modules on smartphones, it is equivalent to the expansion of some functions of smart wristband. Of course, smartphones also have their shortcomings, such as low step counting accuracy when placed in a pocket, and inability to achieve functions such as heart rate detection. The latter is because the sensor module for heart rate monitoring needs to be tightly attached to the skin, and the wrist position is a good choice.

3.3. Intelligent running shoes

In the era of intelligence, the application of technology in the design and manufacturing of sports shoes has shifted from auxiliary to core driving force [27]. In terms of digitization, sensors and chips have become standard, not only recording steps, but also providing professional data such as gait analysis, bounce height, and ground contact time for improving athletic performance and preventing injuries. In terms of intelligence and adaptability, it has surpassed automatic lacing and developed towards adaptive cushioning, power assistance, and other directions. The design principle of the in-shoe pedometer is that it records one step when the heel touches the ground. Usually, designers integrate pressure sensors, circuits, and rechargeable batteries into the interior of ordinary shoe heels, and count steps by detecting the moment the heel touches the ground [28,29]. Some designs integrate the device into the insole to achieve step counting function in ordinary sports shoes, and sell smart insoles separately [30,31].

However, placing step counting devices inside shoes can have many problems, such as hygiene issues, comfort issues, and inconvenient washing and disassembly. The insole is the part that directly contacts the sweat on the feet, which is prone to bacterial growth. But smart insoles cannot be washed with water at will, as long-term use can cause hygiene and odor problems, which are not friendly to foot health. Shoes or insoles inevitably need to be cleaned, but electronic insoles should never be washed or soaked. Once sweating heavily or being exposed to rain, there is a risk of damage.

3.4. Wearable devices for knees

As is well known, step counting devices based on acceleration sensors can also be placed in the knee area and its surrounding areas [32]. There is no essential difference between this form and at the wrist or ankle. In fact, by observing the posture changes of people during walking or running, it can be found that with each step, the knee positions will intersect and meet. Figure 1 vividly illustrates this process and the

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next process will repeat. Therefore, if a step counting scheme can be designed based on this characteristic law, the accuracy will be much higher. A pedometer scheme based on infrared light-emitting and receiving modules is easily thought of. As far as we know, the authorized Chinese invention patent is the first solution to achieve precise counting through knee wearable devices [33].

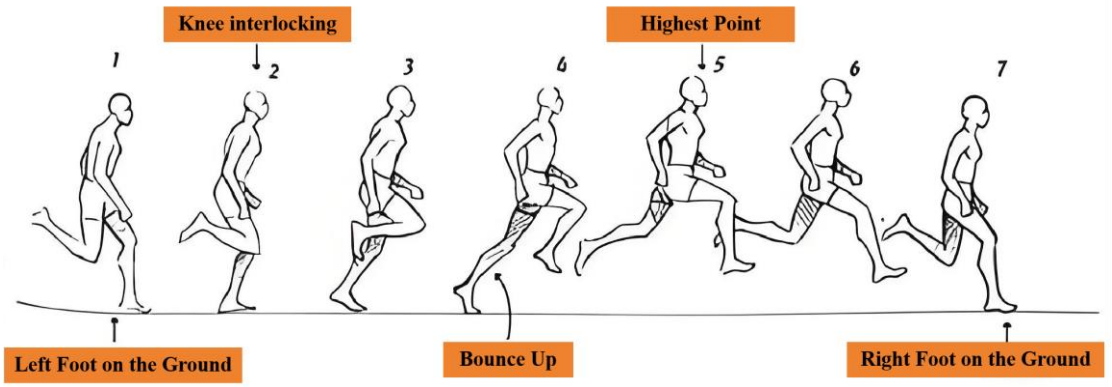

Figure 1: Side display of running posture.

Our previous research work described the implementation principle and technical details of this scheme [34]. It is easy to think that replacing different sensors can also achieve this function, but the fundamental principle is not different.

4. Data Analysis in the Era of Large Language Models

Before the emergence of LLM, step counting data analysis mostly remained at the descriptive statistical level (such as steps, distance, calories). The emergence of LLM has elevated data analysis from "what" to "why" and "how", with its core significance reflected in:

(1) Deep personalized insights and natural language interaction. In the past: You saw 'I took 8000 steps yesterday', but I don't know if it's good or bad, and I don't know how to improve it. LLM era: You can directly ask the device or app, 'What is the trend of my steps this week?'? Why are the steps on Wednesday and Friday so low? ” LLM can comprehensively analyze your calendar (meeting duration), weather data (Wednesday rain), sleep data (Friday sleep deprivation), etc., providing you with a comprehensive explanation in natural language, rather than just cold numbers.

(2) Behavioral motivation and psychological insight. In the past, data analysis was unable to understand your 'motives' and' emotions'. LLM era: By analyzing your voice interaction with the device, combining step count changes with content shared on social media (with user authorization), LLM can infer your emotional state (such as a possible decrease in step count when under stress), exercise preferences, and provide more accurate psychological incentives and content recommendations.

(3) Comprehensive prediction and warning of health risks. In the past, a sudden decrease in steps may just be an outlier. In the LLM era, LLM can combine step data with multiple physiological data such as heart rate variability, sleep quality, and blood oxygen saturation for analysis. It can not only identify the phenomenon of "step count decline", but also correlate and analyze that this may be due to "poor sleep quality recently leading to daytime fatigue", thus giving an early warning of "suggesting you pay attention to rest and adjust exercise intensity", rather than just a reminder of "you have not achieved your goal".

(4) Dynamic development of generative health plans. In the past, exercise plans were usually static and individualized. In the LLM era, you can say: "Help me develop a hiking training plan for next month, with the goal of completing a 15 kilometer hike by the end of the month. I usually sit in the office and have had a slight discomfort in my right knee." LLM will generate a fully personalized and gradual weekly training plan based on your historical step data, intensity distribution, and self-reported health status, and dynamically adjust it according to your actual completion situation during the execution process.

(5) Intelligent management of social and group health. In the past, step ranking was just a simple numerical comparison. In the era of LLM, LLM can analyze collective data of a family or team and

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discover group patterns. For example, it may find that "whenever the team project pressure is high, the daily average steps of all members will decrease", providing managers with insights into organizational health. It can also generate interesting team challenge tasks and deliver inspiring broadcasts in natural language.

5. Conclusion

With the development of intelligent technologies, various intelligent software and hardware have been developed for the field of smart sports. In fact, this is also an inevitable trend in the era of artificial intelligence and a good entry point for combining artificial intelligence with sports. In the future, many jobs that can be replaced by artificial intelligence will be completed by robots or intelligent agents, and humans will focus more on their own health and sports activities.

Considering that less exercise cannot meet health needs and more exercise can harm bones or knee joints, more accurate step counting is crucial. This article reviews several different schemes for step counting, aiming to provide researchers with better ideas and contribute to the development of accurate and interesting step counting devices.

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