LIU, Yongsen, SHAN, Yu, ZHANG, Mufan, JI, Bin and ZHOU, Yang. Digital Divide in Smart Sports Applications for the Elderly and Its Mitigation. Quality in Sport. 2025;40:60013. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.40.60013
https://apcz.umk.pl/QS/article/view/60013

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 02.04.2025. Revised: 04.04.2025. Accepted: 10.04.2025 Published: 14.04.2025.

Digital Divide in Smart Sports Applications for the Elderly and Its Mitigation

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Abstract: Physical exercise for the elderly is not only an inevitable choice for addressing individual health crises but also a strategic necessity for alleviating pressure on medical resources and building an active aging society. Through methods such as literature review and logical analysis, this study focuses on the digital divide faced by the elderly in smart sports applications. By examining the application of smart sports in elderly physical exercise and the manifestations of the digital divide, it proposes mitigation pathways to provide theoretical references and practical insights for constructing an age-friendly digital health ecosystem, thereby enhancing the physical health of the elderly. The research indicates that smart sports applications for the elderly involve five key aspects: health monitoring and risk, personalized exercise prescription systems, virtual reality and immersive training, social motivation, and remote rehabilitation integrated with smart elderly care. The digital divide primarily manifests in three dimensions: technological access barriers, disparities in digital literacy and cognitive abilities, and psychological and social exclusion. At its core, the digital divide reflects a conflict between the logic of technological iteration and the demand for social equity. Based on this, the study constructs a three-dimensional mitigation framework of "technological optimization-social support-policy," proposing solutions through age-friendly technological redesign, multi-stakeholder collaboration mechanisms, and inclusive policy design.

Keywords: elderly; physical exercise; smart sports; digital divide

1. Introduction

With the acceleration of global aging, the population of individuals aged 60 and above in China has reached 280 million [1]., leading to a rigidly growing demand for elderly healthcare. Against this backdrop, physical exercise has become an urgent issue concerning both individual health and social welfare. Recent surveys show that more than 78% of elderly individuals in China suffer from chronic diseases, among which musculoskeletal diseases such as osteoarthritis and sarcopenia are prevalent, directly threatening their ability to live independently [2.3]. Studies have shown that regular exercise can reduce the risk of falls by 41%[4] and slow cognitive decline by 30% [5]. However, the current participation rate of elderly individuals in physical activities remains below 40%, with an even lower rate of 20% in rural areas [6][7].

With the increasing trend of smaller family structures and empty-nest households, the lack of physical activity exacerbates the burden of chronic diseases and psychological loneliness. Furthermore, only 34% of communities are equipped with age-friendly fitness facilities, leading to a severe lag in resource provision [8].

With the rapid development of smart sports technology, digital tools such as smart wristbands and AI fitness mirrors have provided new pathways for elderly physical exercise. As a digital health management tool, smart sports should serve as an essential means to promote active aging. However, behind the empowerment of technology lies a severe digital divide. This divide not only exacerbates the uneven distribution of health resources but also risks further marginalizing vulnerable groups.

Currently, the development of smart sports has fallen into a structural mismatch between "technological supply and elderly demand." Only by systematically studying the formation mechanisms of the digital divide and exploring solutions to bridge it can we avoid technological progress turning into a tool for age discrimination. Instead, smart sports should effectively empower the elderly, improve their physical health, and achieve truly inclusive development in healthy aging. Therefore, this study focuses on the digital divide in the application of smart sports for the elderly, analyzes the manifestations of the digital divide, and proposes targeted solutions. These findings have significant practical implications for leveraging smart sports to promote elderly physical exercise and improve their physical health.

2. Elderly Physical Exercise and Smart Sports

2.1 Elderly Physical Exercise

Elderly physical exercise is a core strategy to address the challenges of population aging. On the physiological level, regular exercise can reduce the risk of cardiovascular diseases by 36%, increase bone density by 17%, and effectively delay the progression of sarcopenia, reducing fall incidence by 41% (WHO data) [9.10]. On the psychological level, collective exercise can activate social neural circuits, enhancing the alleviation of depressive symptoms by 58% [11], and cognitive training combined with aerobic exercise can reduce the risk of Alzheimer's disease by 31% [12]. On the social value level, physical exercise helps reconstruct the social roles of elderly individuals, with participants in community exercise groups experiencing a 2.3 times higher social engagement rate, forming a positive cycle of active aging [13]. From a public health perspective, for every 10% increase in elderly physical activity participation, medical expenses can be reduced by 7.2%, significantly alleviating social security pressures [14]. Physical exercise is not only a means of health maintenance but also an empowering way for elderly individuals to realize their self-worth and rebuild social connections.

2.2 Smart Sports

Smart sports are a new form of sports that integrates the Internet of Things (IoT), big data, artificial intelligence (AI), and other cutting-edge information technologies. Through the deep integration of smart devices, digital platforms, and data analysis, smart sports aim to achieve intelligent sports scenarios, precise health management, and personalized service delivery.

The essence of smart sports is to reconstruct the relationship chain of "people-sports-health" through technological means, overcoming the spatial and temporal limitations of traditional physical exercise and forming a data-driven scientific sports ecosystem.

2.3 The Application of Smart Sports in Elderly Physical Exercise

As society accelerates its aging process, the demand for elderly physical exercise is becoming more diversified. However, traditional exercise models face challenges such as difficulty in monitoring exercise risks, insufficient social incentives, and lack of scientific guidance. Smart sports, through technological empowerment and model innovation, are becoming a key solution to the challenges of promoting elderly health. Smart sports represent an important technological approach to addressing the global aging challenge, particularly in improving the safety, adherence, and health conversion efficiency of elderly exercise. Currently, the applications of smart sports in elderly physical exercise mainly cover five areas:

2.3.1 Health Monitoring and Risk Warning

Current smart sports products, such as smart wristbands and pressure-sensitive insoles, in combination with environmental sensors, can collect real-time physiological indicators (heart rate, blood oxygen, balance) and behavioral data (gait, movement trajectories) during elderly physical activity. This provides the possibility for health monitoring and risk warnings. For example, a smart insole, through pressure distribution analysis, can predict the risk of falls 30 minutes in advance.

2.3.2 Personalized Exercise Prescription System

The personalized exercise prescription systems in smart sports applications can generate dynamic and tailored exercise plans for individuals based on health big data and AI algorithms. In practice, some regional elderly health platforms integrate electronic medical records, genetic testing, and exercise data to customize "aerobic-resistance" combination training plans for diabetes patients. An AI sports coach developed by a company can automatically adjust the training intensity based on real-time fatigue levels of elderly individuals.

2.3.3 Virtual Reality and Immersive Training

Some smart sports products utilize VR/AR technology to create age-friendly exercise scenarios for immersive training. For example, the “Virtual Mountain Climbing System” developed by Panasonic in Japan helps bedridden elderly individuals maintain lower limb strength through visual-vestibular interaction. A community has introduced a VR Tai Chi teaching system that uses motion capture to help elderly individuals correct posture deviations and improve movement accuracy.

2.3.4 Social Incentives

Elderly health not only involves physical well-being but also encompasses mental health and good social adaptation. To enhance the social adaptation and mental health of the elderly, smart sports can reconstruct the spatial and temporal boundaries and social modes of elderly exercise.

Online exercise communities break geographic limitations, and communities can promote elderly participation in exercise by building digital exercise platforms. For example, Tencent has developed the "Silver-haired Exercise Circle" platform, using social algorithms to match "exercise partners," which increased the monthly active rate of elderly users.
An age-friendly exercise app's "Cloud Square Dance" function connects elderly users nationwide, with an average of 250,000 daily active users.

2.3.5 Remote Rehabilitation and Integration with Smart Elderly Care

In the context of medical and physical integration, remote rehabilitation and smart elderly care systems have bridged the gap between medical and exercise services. For example, Shenzhen's "Health and Wellness Integration" platform synchronizes post-surgery rehabilitation plans to the cloud, enabling elderly hip replacement patients to undergo home rehabilitation. A smart elderly care community integrates exercise data with health records, and the AI system automatically triggers nutritional supplementation and physiotherapy services.

3 Manifestations of the Digital Divide in Elderly Smart Sports

The digital divide refers to the systemic disparities between different social groups in terms of access to digital technology, technological competence, and opportunities to benefit from it. These disparities result in the marginalization of certain groups in the digital process. In the context of an aging society, the digital divide among the elderly is particularly prominent. The digital divide in elderly smart sports applications mainly manifests in three areas: technological access barriers, differences in digital capability and cognition, and psychological and social exclusion.

3.1 Technological Access Barriers

With the rapid development of smart sports, the difficulty elderly individuals face in accessing digital exercise services due to technological access barriers has become increasingly prominent. Technological access barriers primarily manifest in three dimensions: weak network infrastructure, unfriendly user interfaces, and these structural obstacles severely limit the fairness and accessibility of elderly participation in smart sports. These include the following aspects:

3.1.1 Difficulty in Acquiring Hardware Devices

The application of smart sports in exercise requires both software and hardware as its foundation, which falls under the category of technological access issues. Hardware such as fitness trackers, AI fitness mirrors, and other smart devices are essential, but their ownership among the elderly is relatively low. Economic limitations are one of the main reasons for the low ownership rate. In first-tier cities, the penetration rate of smart fitness trackers among the elderly is 42%, while in rural areas, over 70% of elderly individuals report being "unable to afford devices priced over 1,000 yuan" [15].

3.1.2 Weak Network Infrastructure

Regarding network access, data from the National Bureau of Statistics in 2023 show that while 5G network coverage in administrative villages reached 98%, the actual bandwidth compliance rate (≥100 Mbps) is less than 60% [16], which makes high-traffic applications such as video guidance and real-time data synchronization difficult to operate smoothly.

3.1.3 Unfriendly User Interfaces

Existing smart sports devices generally suffer from a "technology-heavy, experience-light" design flaw. A 2024 evaluation of 20 mainstream sports apps by Fudan University revealed that only six apps were certified under the national "Mobile Internet Application Age-Friendly General Design Standards." Over 80% of the apps exhibited issues such as overly deep functional entry levels (requiring an average of 5.2 clicks), small font sizes (default font size ≤ 12px), and more. Elderly individuals, due to cognitive decline and reduced touch sensitivity, experience a strong sense of frustration when faced with complex operations. Additionally, the mismatch between device functions and needs is prominent. For example, mainstream smartwatches focus on features favored by younger users, such as heart rate monitoring and exercise tracking, but lack modules that are essential for the elderly, such as fall warnings and medication reminders, leading to the awkward situation of having "devices with little practicality."

3.2 Differences in Digital Capability and Cognition

In the application of smart sports, the differences in digital capability and cognition among the elderly are core factors exacerbating the digital divide. These differences are not only reflected in the technical operation level but also involve deeper aspects such as understanding health data, information processing efficiency, and psychological adaptability, making it difficult for elderly individuals to effectively use digital tools to enhance their exercise and health levels. This includes the following aspects:

3.2.1 Insufficient Technical Learning Ability and Health Data Literacy

Elderly individuals generally face steep learning curves with new technology. The 2023 "China Elderly Digital Health Report" shows that only 18% of the elderly can independently complete basic operations such as registering accounts and synchronizing data on fitness apps, while over 50% require assistance from children or community volunteers. Even more critically, the lack of health data literacy means that elderly individuals struggle to understand the professional metrics generated by smart devices. This cognitive gap may lead to misjudging exercise risks, such as mistaking abnormal heart rates for equipment malfunctions, thereby causing them to abandon usage.

3.2.2 Cognitive Aging and Reduced Information Processing Efficiency

Cognitive decline in the elderly (such as reduced working memory and lower attention distribution capabilities) significantly affects the efficiency of using smart sports tools.

Experimental studies show that elderly individuals take 2.3 times longer than younger individuals to complete the process of "selecting a course, adjusting difficulty, and starting the exercise" on an AI fitness mirror, with an error rate as high as 47% [17]. Additionally, a lack of multitasking ability increases frustration: when devices provide simultaneous voice prompts, screen animations, and touch feedback, elderly individuals experience "information overload," which leads to action execution deviations.

3.2.3 Technological Anxiety and Loss of Self-Efficacy

The differences in digital capability further trigger psychological exclusion. A 2024 survey by AARP (American Association of Retired Persons) revealed that 52% of elderly individuals refuse to try smart fitness tools due to concerns about making mistakes and damaging the equipment, and 31% believe "they will never learn new technology" [18]. This low self-efficacy creates a vicious cycle: the more they avoid trying, the worse their digital capabilities become.

3.3 Psychological and Social Exclusion

In the promotion of smart sports, the psychological and social exclusion of the elderly are intertwined, deepening and complicating the digital divide. Specifically, this manifests in two ways:

3.3.1 Psychological Exclusion among the Elderly

Elderly individuals generally experience technological anxiety and psychological exclusion in smart sports applications, which become significant factors in deepening the digital divide. Surveys show that 52% of elderly individuals refuse to use smart fitness tools due to concerns about damaging the equipment, and 31% have strong anxiety over data privacy breaches (such as misuse of sensitive information like heart rates and locations). This exclusion stems from multiple psychological mechanisms [19]: first, a lack of self-efficacy, with over 60% of elderly individuals believing "new technology is for young people, and they cannot master it"; second, social comparison pressure, where real-time data rankings in smart fitness scenarios exacerbate the feeling of "technological disadvantage," causing 45% of elderly individuals to actively avoid smart devices; third, generational cultural gaps, with some elderly individuals viewing technology as a "dehumanizing" threat, believing that AI coaches lack the warmth of human interaction and cannot replace traditional social connections. Psychological exclusion not only weakens the willingness to use technology but may also trigger an "identity crisis" of "technological marginalization," which urgently requires intervention through emotional design, positive incentives, and social support networks [20].

3.3.2 Social Exclusion

The digital process of smart sports has exacerbated the social exclusion of the elderly, manifesting in multi-dimensional marginalization in resource allocation, participation opportunities, and social recognition. First, community smart fitness facilities are mostly designed based on the needs of younger users; second, in intergenerational family interactions, children share health data through fitness apps, while elderly individuals are excluded from the "digital health social circle" due to technical barriers, reinforcing their sense of loneliness.

Moreover, in policy formulation and technological promotion, elderly voices are often absent, such as when smart sports project bids rarely address elderly needs, further deepening structural exclusion. Social exclusion not only deprives elderly individuals of their health rights but also erodes their sense of social belonging, requiring the reconstruction of the participation ecosystem through inclusive policies and intergenerational support mechanisms.

4 Solutions to the Digital Divide in the Application of Smart Sports for the Elderly

Research by the World Health Organization suggests that bridging such a digital divide can enhance the efficiency of elderly health interventions. Based on the manifestation of the digital divide in smart sports applications for the elderly, the digital divide problem in elderly smart sports applications is essentially a structural imbalance between technological empowerment and the adaptability of the elderly population, manifesting in systemic exclusion across four dimensions: technology access, usage efficiency, value transformation, and ethical rights. Firstly, there is a physical exclusion due to the technological access gap caused by economic cost barriers. Secondly, functional exclusion arises from mismatched interaction design and the digital literacy gap. Thirdly, value exclusion in application efficiency is caused by low health conversion efficiency and ineffective social incentives. Finally, ethical exclusion in rights is caused by algorithmic age discrimination, data rights deprivation, and the marginalization of social roles. Currently, the digital divide has deepened from the "access gap" to the "ability gap" and "psychological gap," prompting the construction of a three-dimensional solution framework based on "technological optimization - social support - policy guarantee." The aim is to break the impasse through age-friendly technology reconstruction, multi-stakeholder cooperation mechanisms, and inclusive policy design.

4.1 Age-Friendly Technology Design

Technology serves as the vehicle for empowering elderly people’s physical exercise through smart sports. Systematic technological innovation is required to make smart sports a true tool for elderly health management, thereby breaking the digital divide. Technological innovation involves reducing costs to promote its dissemination and optimizing interaction interfaces to enhance its application. Research optimizes technology based on the progressive logic of “cognitive load reduction - trust building - social integration.” Firstly, through interaction simplification and multi-modal design, we can overcome physiological and cognitive barriers to lower the usage threshold. Secondly, by strengthening privacy protection and transparent design, trust in technology can be rebuilt to enhance the sense of control. Finally, by reconstructing the participation ecosystem and establishing a "family-community linked technology," a sense of social belonging can be promoted. Specific paths are outlined as follows:

4.1.1 Deep Age-Friendly Design Reconstruction

Firstly, by enforcing a "senior-first" design standard, we can ensure the simplification of usage interfaces and reduce cognitive load in elderly people's use of smart sports. For example, the functional entrances of devices should not exceed three levels, font sizes should be ≥18px, and core buttons should have an area of ≥1cm² with high contrast color schemes (such as yellow background with black text).

Currently, Huawei's sports health app has initiated a “Senior Mode” based on these standards, which has increased the daily active rate of elderly users. Secondly, dynamic adaptation technology can be developed to simplify the function layout based on the user’s operation habits (such as click frequency or error type). For example, Xiaomi’s Mi Band introduced a "learning mode," where if frequent errors in the heart rate module are detected in elderly users, secondary features are automatically hidden, keeping only the fall warning and step count functions.

4.1.2 Multi-Modal Interaction Technology Integration

Multi-modal interaction technology can integrate voice, gestures, and tactile feedback. For example, voice-gesture control could be developed, supporting dialect recognition for voice interaction (e.g., Cantonese, Sichuan dialect) combined with gesture sensing (e.g., waving to pause, fist gesture to confirm). This reduces dependence on touch screens. Currently, Alibaba’s "Luban AI Fitness Mirror" has a dialect recognition accuracy rate of 92%. Additionally, tactile feedback can be integrated into smart devices to reinforce guidance, such as using vibration motors in devices to transmit key information through varying vibration strength or frequency. For example, a smart jump rope handle vibrates at a high frequency when the heart rate exceeds a threshold, avoiding the elderly from relying on visual monitoring.

4.1.3 Lightweight AI Assistance

Using edge computing technology, real-time motion correction can be implemented on local devices, enabling risk warning and adaptive guidance. For instance, the AI Tai Chi Mirror uses a lightweight skeletal point algorithm to feedback posture deviations within 0.2 seconds, avoiding delays from cloud computing. Additionally, Bluetooth/Wi-Fi automatic seamless switching technology can be developed so that elderly users do not need to manually operate to upload exercise data, achieving "invisible" data synchronization.

4.1.4 Privacy Protection and Trust Enhancement Technology

The collection, storage, and feedback of exercise data involve data security concerns, which can be improved by minimizing data collection and ensuring transparent data flow. Firstly, only essential movement indicators (e.g., steps, heart rate) should be collected, and GPS positioning should be disabled by default. Secondly, a visual permission management system can be developed, allowing elderly users to intuitively view the data usage path through a "data flow map." For example, Tencent’s sports health app added a "privacy sandbox" feature, which allows users to withdraw third-party data authorizations with one click.

4.1.5 Offline-Online Hybrid Mode

Given the limitations of elderly people’s wireless network usage and network coverage, this can be alleviated through localized content caching and low bandwidth optimization. For example, pre-installing offline basic courses (such as Ba Duan Jin teaching videos) and supporting U-disk updates. Currently, Huawei has launched an "offline exercise package" in collaboration with the National Sports Administration, covering 98% of community fitness needs.

4.1.6 Community-Family Linked Technology Ecosystem

Elderly fitness devices can also incorporate family and community technological care, forming a community-family linked technology ecosystem. For example, a family account coordination system can be developed, ensuring that children's apps can remotely set exercise plans for their parents' devices and receive abnormal alerts.

At the community level, a digital twin system can be established to create virtual fitness communities, enabling elderly users to participate in online group exercises (e.g., square dance live broadcasts) via TV screens, reducing operational complexity.

4.2 Multi-Agent Collaborative Support System

The core of a multi-agent collaborative support system lies in breaking down resource silos and strengthening shared responsibility. Through institutional design and technological innovation, it transforms elderly individuals from being "marginalized users" of smart sports into "core service recipients." Existing research has demonstrated the effectiveness of such initiatives. For example, Shanghai's pilot project, "Digital Fitness Instructors," enhances usage by 40% within six months through community-family collaboration and training, where volunteers teach elderly individuals how to use smart treadmills at home. In Finland, the "Tech-Grandpal" program promotes cross-generational digital mentoring, encouraging youth to pair with elderly people to learn how to use fitness apps. Studies show that elderly individuals' digital confidence significantly increased [21]. In Japan, the government-corporate-community collaboration initiative provides free AI fitness mirrors to people over 65, with community instructors offering weekly in-home teaching. Coupled with the national health insurance system, those meeting certain fitness standards are eligible for premium reductions. After three years of implementation, the incidence of sarcopenia among the elderly dropped by 23%, and healthcare spending decreased by 18% [22]. Thus, this approach has significant reference value. The digital divide for the elderly in smart sports applications requires multi-agent collaboration from government, enterprises, communities, families, and social organizations to build a comprehensive support system encompassing technology development, resource allocation, educational support, and emotional care. The following outlines the specific implementation pathways:

4.2.1 Government Leadership

As the policy maker and resource allocator, the government should play a leading role in policy protection and public resource distribution. Specifically, relevant policies should be introduced to encourage and support enterprises to develop smart sports applications suitable for the elderly. For example, the government can provide tax incentives or subsidies to motivate enterprises to design elder-friendly products. Additionally, the government needs to strengthen infrastructure development, such as enhancing internet coverage in rural areas, ensuring elderly individuals can effectively use these applications. By establishing an "Elderly Smart Sports Special Fund," public resources can be redirected.

Furthermore, the development of age-friendly technical standards, such as the "General Design Guidelines for Mobile Internet Applications for the Elderly," should be enforced, requiring smart sports applications to comply with guidelines such as limiting interface layers to ≤3 levels and ensuring core functions are accessible with a single click. Enterprises that meet these standards should be granted tax reductions. Lastly, a cross-departmental collaboration mechanism should be established, involving the health, civil affairs, and sports departments to form a "Physical Health and Medical Integration Service Station," where smart sports data is integrated into basic health records to seamlessly connect exercise interventions with chronic disease management.

4.2.2 Enterprise Innovation

As the provider of smart sports products, enterprises should assist in bridging the digital divide for the elderly in both technical adaptation and inclusive supply. As the primary developers of technology, enterprises should design user-friendly and accessible interfaces based on the elderly's specific needs. In practice, a team of elderly user experience officers can be formed to participate in the product development process. During product cost control, enterprises should initiate low-cost elderly-friendly device development projects, such as designing budget-friendly smart wristbands (e.g., Xiaomi's "Silver Guardian Edition"), integrating essential features like fall detection and medication reminders, and reducing product costs through large-scale production. Furthermore, enterprises can collaborate with communities to provide training and guidance sessions to help the elderly familiarize themselves with these applications, ensuring inclusive supply. In terms of data openness, enterprises can promote inclusive access through interconnected data and open API interfaces, allowing community hospitals to retrieve elderly users' exercise data, which can help family doctors create personalized health plans.

4.2.3 Community Empowerment

Communities, as grassroots organizations directly engaged with the elderly, can assist through localized services and social network building. In terms of localized services, a "Digital Fitness Instructor" system can be established, where each community is equipped with 1-2 certified instructors who offer one-stop services such as "home teaching, regular follow-up visits, and troubleshooting." Regular training sessions can be organized, inviting professionals or volunteers to teach elderly individuals how to use smart sports devices. Additionally, community smart sports service stations can be set up to provide temporary device loans and emergency data interpretation services (e.g., ECG anomaly alerts) to reduce the perceived risk of using technology. A technical support hotline can be established to address issues that arise during usage. In terms of social network building, offline and online mixed exercise communities can be created. Communities can also set up mutual aid groups to encourage elderly individuals to assist one another and share usage experiences.

4.2.4 Family Support

Families play a crucial role in encouraging elderly individuals to use smart sports applications. By fostering intergenerational interaction and emotional support, family members can increase the elderly's willingness and confidence in using these applications. For instance, implementing a "1+N" family digital coach system, where each elderly person is assisted by one primary family member (child or grandchild) and several community volunteers, can help solve usage issues through remote assistance (such as screen sharing). Additionally, family health data sharing can allow children to monitor their parents' exercise data in real time, receive alerts for abnormalities, and set up "intergenerational fitness challenges."

4.2.5 Social Organization Supplementation

Social organizations, as part of the "third sector" in modern society, can fill the functional gaps between government and market. Their flexibility and close connection to grassroots make them uniquely valuable in addressing the digital divide among the elderly. They can contribute through cultural adaptation and providing support for vulnerable groups. For example, AI fitness assistants that support languages such as Tibetan, Cantonese, and other regional dialects could be developed to facilitate cultural adaptation. Additionally, providing free device rentals and in-home guidance for elderly individuals who are disabled or have low incomes can assist vulnerable groups in gaining access to technology.

The digital divide among the elderly is not an individual issue but a collective problem. The deeper contradiction behind the digital divide is the conflict between the logic of technological iteration and social equity demands. Therefore, a multi-agent collaboration approach is needed to resolve this issue. Naturally, elderly individuals themselves should also actively participate and take the initiative to learn new technologies. Despite facing cognitive and physical challenges, with continuous learning and practice, they can gradually acquire the necessary digital skills. Society should encourage the elderly to maintain a positive learning attitude and provide corresponding learning resources and support.

4.3 Inclusive Policy Design

As a tool of national governance, policies can address social issues, promote fairness and justice, and achieve sustainable development through resource allocation, behavioral guidance, and institutional constraints. The digital divide in the application of smart sports for the elderly not only manifests as a barrier to technological access but also involves deeper contradictions in social resource distribution, cultural adaptation, and the protection of rights. Therefore, policy design is the prerequisite for solving this issue. The essence of inclusive policy design is to calibrate the direction of technological civilization development. It must transcend the "instrumental gap-filling" mindset and build three intervention mechanisms: technology governance, economic incentive, and rights protection.

4.3.1 Technology Governance Mechanism

This mechanism should establish a "demand-side reform" that forces supply-side innovation, transforming age-friendly design from a cost burden into a value opportunity. In the construction of this mechanism, technology governance can be achieved through mandatory adaptation standards and the establishment of public technology platforms. For example, all smart sports devices should be required to pass the "Elderly Mode" certification; the government can build an open-source age-friendly component library (providing free large-font UI templates and voice interaction SDKs).

4.3.2 Economic Incentive Mechanism

At the economic level, tax incentives for research and development and social responsibility investment can guarantee savings and capital injection. For instance, enterprises developing age-friendly fitness devices could enjoy corporate income tax reductions. Including age-friendly digital services within the ESG (Environmental, Social, and Governance) evaluation system would guide the capital market to direct support to such enterprises.

4.3.3 Rights Protection Mechanism

In terms of rights protection, a digital guardianship system and algorithm auditing system should be established. For example, a "digital guardian" should be appointed for elderly individuals with cognitive decline to prevent technological misuse; third-party institutions could be introduced to regularly audit the recommendation logic of fitness apps to ensure that they do not discriminate against the elderly.

5 Conclusion

Smart sports should not become a "digital wall" dividing generations but should transform into a bridge that connects life courses and enhances social cohesion. The digital divide in the application of smart sports for the elderly is essentially a deep contradiction between rapid technological development and the demand for social fairness. This contradiction not only manifests as operational barriers for elderly individuals using smart devices but also reflects structural dilemmas such as imbalanced resource allocation, inadequate rights protection, and insufficient cultural adaptation in the digital age. Bridging this divide can not only unlock the potential of the "silver economy" but also reshape the value consensus of "active aging," providing a practical model for building an age-friendly society.

Disclosure

Author's contribution

This article is designed and written by Yongsen Liu and Yu Shan. Mufan Zhang and Bin Ji are responsible for literature collection and organization. Meanwhile, Yang Zhou is the project manager and has approved the author and corresponding author of this study.

All authors have read and agreed with the published version of the manuscript.

Financing Statement

The research project on educational and teaching reform at Southwest University, titled "Measurement of Sports Literacy and Cultivation Pathways for College Students in Chongqing," Project Number: 5240201654.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflict of interest

The authors deny any conflict of interest.

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