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Intelligent Transformation of Fitness Industry Based on Experimental Analysis: Evidence from the Fitness Apps by Chinese College Students

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The latest generation of digital technology raises new opportunities and challenges for the development of the physical fitness industry. How to improve the impact of fitness apps on college students' exercise is a current research hot-spot. The purpose of this study was to explore the macro environment and micro scenario of the intelligent transformation of the physical fitness industry in the Chinese context. The study investigates the dynamic framework of China's fitness industry and explores the influence of fitness apps on college students'(N=604) physical and mental well-being. SPSS 22.0 was used to conduct data analysis. The following conclusions were reached: (1) Fitness apps were positively associated with college students' well-being($p<0.01$); (2) Personal exercise via fitness apps mediated the relationship between college students' mental and physical health; (3) College students exercise adherence as well as subjective exercise experience and exercise adherence.

Keywords: fitness apps; digital technology; intelligent transformation; college students

1. INTRODUCTION

China is a large leisure sports country with a population of nearly 1.4 billion, nearly 500 million people who regularly participate in sports activities and nearly 700 million people who participate in leisure sports. The 56 ethnic groups in China have many leisure activities and leisure pursuits, most of which involve leisure and fitness sports. As Li pointed out, China is not yet a powerful nation in terms of the physical fitness industry. The fitness industry can do much to ensure that China, with one of the world's largest sports sectors, can become one of the most powerful nations in terms of fitness [1]. In this study, we explore the macro environment and micro scenario of the sustainable development of the physical fitness industry in China.

On the one hand, with the continuous development of China's modernization and the improvement of the economic development level, the sports industry is contributing a big share to the GDP to promote China's economic development. On December 30, 2022, the State Sports General Administration and the National Bureau of Statistics jointly released the data on the total scale and added value of the national sports industry in 2021. The total scale (total output) of the national sports industry in 2021 was estimated at 3,117.5

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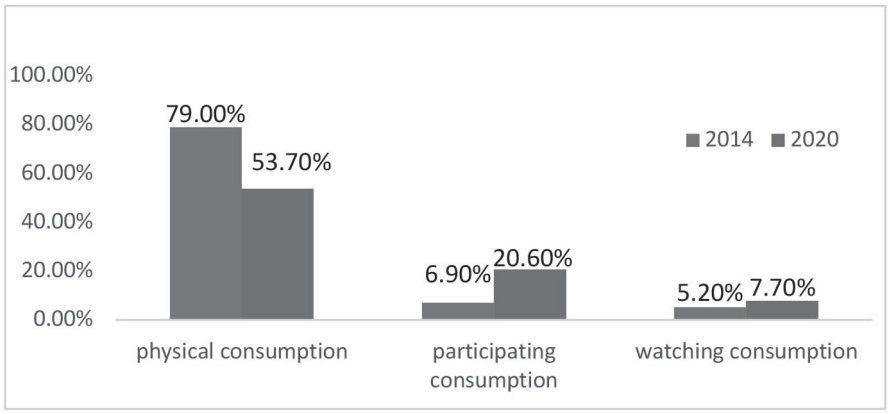

Figure 1 The proportion of the three types of sports consumption among adults and the elderly in 2014 and 2020.

billion yuan, with an added value of 1,224.5 billion yuan. The added value of the sports service industry was 857.6-billion-yuan, accounting for 70.0% of the added value of the sports industry, an increase of 1.3% over the previous year. Among the added value of sports, fitness and leisure activities increased by 21.1%, and the added value of sports media and information services (non-contact activities)maintained rapid growth, reaching 19.9% [2]. According to international practice, the sports industry should be regarded as a pillar industry of the national economy given that the physical fitness industry of a developed country contributes between 2% and 3% to the development of the national economy, while China's sports industry accounts for less than 2%.

On the other hand, the digital economy is contributing to sustainable development, and the fitness and leisure sports industry is a constituent part of the modern economy. From 2016 to 2020, with the upgrading of residents' consumption structure, the Five Major Happiness industries (Tourism, Culture, Sports, Health, and Pension plan) developed rapidly, continuously promoting the green and sustainable development of the social environment [3]. In 2022, among the service enterprises above the designated size, the combined operating income of the five major happiness industries increased by 14.6%, which is 1.6% higher than the overall growth rate of all service industries. Among them, the operating income of the sports service industry grew the fastest year-on-year, reaching 24.4% [4]. China's physical fitness industry has broad prospects and huge potential and is expected to become a new driving force for economic development and consumption upgrades.

Dixon et al. pointed out that the sports industry itself has great development potential, and with the development of the economy, consumption capacity is also constantly increasing, with the fitness and leisure industry becoming increasingly popular. Because of the COVID-19 pandemic, with the support of digital economy technology, the non-contact sports and leisure industry gradually underwent digital transformation and upgrading, with the online fitness and leisure model as an outstanding representative of the digital trend [5]. Data from the WHO official website shows that at the end of 2022, more than 80% of adolescents and 27% of adults did not meet WHO's recommended levels of physical activity. Four years after GAPPA(Global Action Plan on Physical Activity) the first Global status report on physical activity charts progress on country implementation of these recommendations to achieve the global target of a 15% relative reduction in the prevalence of physical inactivity by 2030 [6].

Intelligent transitions in the sports industry have become an important means of promoting public health and achieving green development. The fitness and leisure industry, as a constituent part of the modern digital economy, is also a sunrise industry developed to encourage an intelligent and healthy lifestyle. Hence, the physical fitness industry will be accepted by an increasing number of people and promote China's digital economic development. The Survey Bulletin on National Fitness Activities 2020, released by the official website of the General Administration of Sports of the Chinese Government, presents the significant changes that have taken place in the sports consumption structure [7]. In terms of consumption types (Figure 1), adults and senior citizens' physical consumption accounted for 53.7% of sports consumption in 2020, a decrease of 25.3% compared with the 2014 survey results: participation consumption and viewing consumption accounted for 20.6% and 7.7% respectively. Compared with the survey results for 2014, they increased by 13.7% and 2.5% respectively. Significant changes have taken place in the sports consumption structure, the consumption tendency has gradually shifted from physical objects to participation and viewing consumption, and the sports consumption structure has been optimized and upgraded.

1.1 Current Situation Observation and Related Study Review

How to transfer China from a large sports population country to a sports power? The former President of World Leisure Sports Association (http://www.worldleisuresports.org/#), Prof. Xiangru Li (2012) claimed that by examining the development of the physical fitness industry in European and American countries, China could be inspired to implement the following: use society and the market as the core strengths to promote its development. Secondly, change the mind set of the general public so that the structure of leisure sports consumption is changed and the industry is upgraded. Thirdly, create a health-aware culture so as to promote the development of modern society [8].

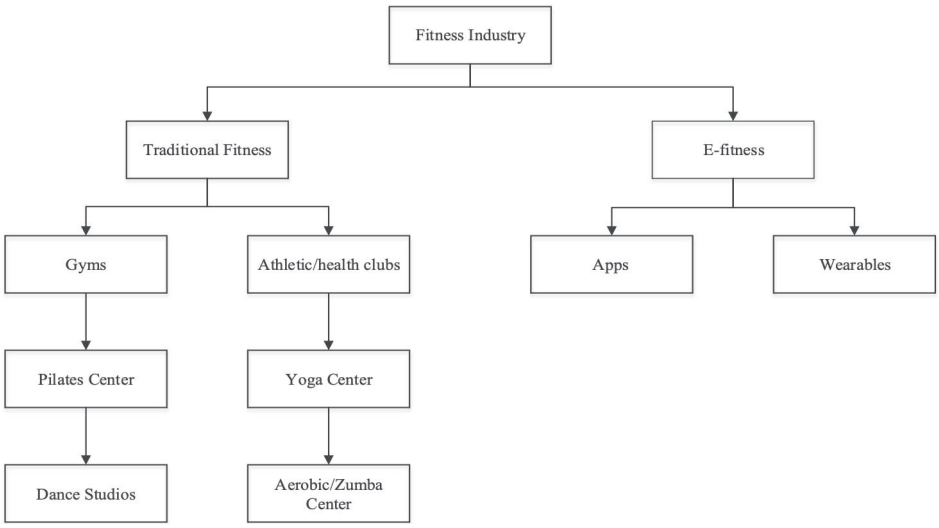

Figure 2 The structure of fitness industry.

Initially, the relevant literature was reviewed and cases were analysed. During the research process, PESTEL strategic analysis, online questionnaires, and systematic reviews were used to assess, predict, and promote usage willingness, coordinated development trends, and intelligent transformation of the fitness industry. To investigate and explore the sustainable development approach of Chinese college students' physical fitness under the digital economic development model, this study employed the macro-economic strategic management PESREL model, and micro-economic management model to investigate the macro and micro factors influencing the physical fitness industry.

1.2 Key Terms

1.2.1 Physical Fitness and Fitness Industry

Physical fitness is defined as 'the capacity to perform daily physical activity without a significant effort', and is based on several factors: cardio respiratory fitness, muscular fitness, flexibility, speed and body composition. Evidence suggests that higher levels of physical fitness in youth may have beneficial effects on cardiovascular, pulmonary and metabolic diseases, and can even reduce the risk of all-round mortality [9]. Among many factors being associated with physical fitness, those included in a healthy lifestyle (appropriate diet, regular physical activity and sport participation, adequate sleep, less time spent in sedentary behaviors) are probably the most important which affect the level of physical fitness. Although efforts have been made to increase people's physical fitness, social trends in the past two decades have suggested a significant decline in cardio respiratory and muscular fitness, while an increase in body composition (predominantly body mass index and the percentage of fat mass) has been observed. Moreover, participation in sports activities has steadily declined in the past years, particularly when students make the transition to higher education.

As shown in Figure 2, the fitness industry can be divided into two categories: traditional fitness and e-fitness. The former involves different types of fitness centers, and an individual must choose a fitness center based on types of amenities required to meet fitness goals. These fitness centers provide physical activities based on how much time one has and the activity that they enjoy the most. Some of the common fitness centers are: gyms, pilates center, yoga center, aerobic center, health clubs and dance studios. With the development of digital technology, E-fitness providers two product categories. This first category is portable connected fitness devices or wearables. These are mainly wearable devices designed especially for fitness-related activities. Fitness wrists are a common wearable device equipped with sensors that analyze physical activity, body functions, steps taken, pulse etc. to determine an individuals' health status. These wearables also include smart clothes and eye wear, but not smart watches. The other category is digital fitness and nutritional applications (apps). These include fitness and nutrition apps, calorie counters, and nutrition diaries, apps for detecting/tracking/analyzing and sharing vitality and fitness achievements. The revenue figures of the segment comprise only paid versions of the app downloads, premium versions or in-app purchases [10].

1.2.2 Intelligent Transformation of Fitness Industry

Maguire stated that there are three branches of the leisure and fitness industry: physical LFI, social LFI and digital economy LFI [11]. The material form of leisure sports consumption comprises physical products such as sports goods, equipment and facilities. Consumers acquire subjective consumption desire from buying sports goods; in terms of social culture, leisure sports are reflected in the social and cultural enjoyment and communicative consumption experience offered by leisure sports to consumers. In terms of the digital economy, leisure sports are manifested as service consumption expenditure and information consumption expenditure. Tsourela conducted a study to compare online and offline fitness training, finding that online fitness can satisfy consumers' physical and mental needs and promotes their physical and mental health development by means of the online fitness industry [12].

Table 1 Functions of digital technology for the intelligent transformation of fitness sports venues.

Functions	Design	Construction	Operation	Services	Maintenance
BIM	v	v			
Internet of things			√	√	√
5G			√	√	√
Cloud computing		√			√
Big data			√	√	√
Block-chain				√	√
Human-computer interaction			√	√	

Digital technology is a collection of applications including 5G, Internet of Things, big data, block-chain, cloud computing, digital twins, artificial intelligence, etc. and intelligent applications at different levels. Table 1 shows the main functions of digital technology applied in physical fitness sport venues. The functional value of plat formisation, digitalization and networking contained in digital technology can form a twin virtual space of "digital world" and "physical world", thereby activating matching effects, spill over effects and multiplier effects.

With digital technologies such as big data, Internet of Things, artificial intelligence and block-chain constantly emerging, new sports products, new scenes, leisure and fitness sports tend to be digital and intelligent, evident by their widespread presence on online fitness platforms and smart venues.

In recent years, smart sports have become increasingly popular, offering more ways for the public to participate in and enjoy sports. This is seen in online fitness guidance, online venue reservation, sports data management, and sports community building.

In March 2022, the General Office of the CPC Central Committee issued the "Opinions on Building a Higher-level National Fitness Public Service System", proposing that by 2035, a national fitness public service system compatible with socialist modernized countries will be fully established, and will speed up the use of 5G and other new-generation information technology improvements for venue management and event services [13]. As an important provider of mass fitness, sports venues must meet higher standards in terms of public consumption capacity and per capita disposable space construction scale. To successfully implement the national fitness strategy and build a better public sports service system for national fitness, the role of sports venues is indispensable [14]. In the era of digitized economies, the intelligent transformation of the fitness industry is imperative.

1.2.3 Fitness Apps

With the improvement of residents' standard of living, they now pay more attention to their health and quality of life. People's enthusiasm for participating in sports is increasing, and various forms of mobile fitness applications have timely emerged, showing an explosion of growth. By June 2018, China had 142 million users of mobile fitness apps. As of February 2019, the number of online sports and fitness apps in China had reached 9,944 (China Industry Information Network) [15].

In terms of the physical fitness industry, existing research tends to focus mainly on the application of new infrastructure in the sports industry. For example, technologies such as big data, 5G, and block-chain in new infrastructure can continuously reshape the organizational structure, management model, and consumption value of the sports industry while becoming key production factors. With the help of new infrastructure, it can replace and transform the operation process of traditional stadiums, live events, mass consumption and other fields, and provide a more convenient, comfortable, environmentally friendly and participatory venue service experience. With the help of Internet of Things technology, users, coaches, and fitness equipment are connected to help improve the user's coaching efficiency and fitness effect.

Aldossan et al. found that mobile fitness apps have a positive intervention effect on people, helping them to develop good exercise habits, control body quality and maintain health. However, despite the advantages of these mobile fitness apps, there is limited understanding of the drivers that motivate individuals to download and use them [16]. Compared with traditional fitness methods that are more demanding in terms of time, venue and other factors, fitness apps are flexible, efficient and convenient, and can adapt to the modern fast-paced lifestyle. In particular, the functions of mobile fitness apps can fully meet the needs of the public for health and fitness aligned withthe goals of achieving national fitness and a low-carbon economy.

In order of popularity, the most widespread fitness apps in China measured by the number of monthly active users and their engagement, are: Keep, Yodo Run, Joy-run, Coodon, and Pacer. Keep is an app created by Beijing Calories Technology Company Ltd (https://www.gotokeep.com/). This fitness app, that provides online fitness programs, topped in the sports app ranking in China with about 14 million monthly active users. The success of Keep is due to the combination of Instagram-style social media and e-commerce functions. Apart from sports enthusiasts benefitting from Keep, business brands also promote their sales in the app's own sports store and create social campaigns in the community space. As more Chinese pursue a healthy and active lifestyle, the fitness industry in China is expected to thrive. Hong surveyed 639 fitness app users and found that the consumption of top fitness apps has continued to grow consistently after the emergence of COVID-19, suggesting that the new habits formed during the pandemic may be permanent [17].

In order to address the macro shortcomings of qualitative research, this study adopts the quantitative research method of conducting an online questionnaire and unstructured

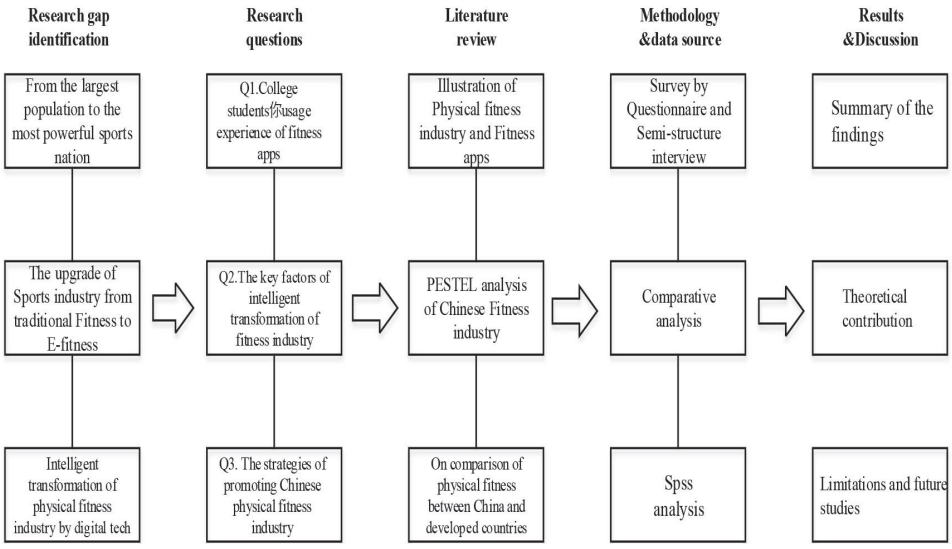

Figure 3 Research road-map.

interviews. A survey was conducted of 604 college students from three colleges located in the central and eastern regions of China. SPSS20 was used to investigate the current situation, willingness to adapt, and participants' feelings about,and attitudes to,using fitness apps.

2. METHOD

2.1 Research Questions and Methodology

Q1. What is Chinese college students' experience of using mobile fitness apps?
Q2. What are the key factors of intelligent transformation of physical fitness industry that can be facilitated by fitness apps?
Q3. How can digital technology be used to promote the intelligent transformation of the physical fitness industry?

Hypothesis 1: Fitness apps are positively related to college students' adherence to a fitness regime.

Hypothesis 2: Fitness apps improve college students' level of fitness and sense of achievement.

Hypothesis 3: Fitness apps improve college students' self-efficacy and enhance their personal exercise experience.

Figure 3 depicts the steps taken in this research. Firstly, we examine the important value and theoretical mechanism of intelligent transformation of the fitness industry by means of digital technology. Secondly, we formulate the research questions and design the case study. In the third step, we analyze the fitness apps in practical application scenarios and Codon systematically examine typical cases. In the Conclusion, we put forward the overall promotion strategy for the optimization of the fitness industry structure, the integration of format and the improvement of efficiency at macro, meso, and micro levels.

2.2 Methodology and Data Collection

PESTEL is modified by adding environmental factors (Ecological) and legal factors (Legal) based on PEST analysis, which was proposed by the American scholars Johnson et al. in 1999. According to Johnson et al., six macro factors are considered when analyzing the context of a business group [18]. The PESTEL analysis is an instrument used to support strategic planning of an organization or company by providing insights on the external environment. PESTEL is an acronym representing each factor associated with the business macro-environment. 'P' refers to the political forces and related policies, laws and regulations that have actual and potential impact on the organization's business activities. 'E' standards for the economic structure, industrial layout, resource status, economic development level and future economic trends outside the organization. 'S' refers to the historical development, cultural traditions, values, education level and customs of members in the society in which the organization is located. 'T' means the technical elements including not only the inventions that have revolutionized the changes, but also the emergence and development trends and application prospects of new technologies, new processes, new materials related to enterprise production. 'E' refers to an element of an organization's activities, products, or services that interacts with the environment. 'L' stands for the comprehensive system of laws, regulations, judicial conditions, and citizens' legal awareness outside the organization.

This study was approved by the institutional review board at Hubei University of Science and Technology. A sequential explanatory mixed-method design was used for this study, comprising two distinct phases. Phase 1 involved quantitative research that helped to identify determinants of Chinese college students' intention to continue using fitness apps. A self-reported questionnaire was completed by 604 college students to ascertain their opinions and experience. Phase 2 constituted qualitative research using semi-structured interviews with a sample of 10 college students. Phase 2 was conducted to complement the findings from Phase 1.

2.3 Measures

Based on information system research, the researcher designed a questionnaire for the fitness application scenarios of Chinese College students. Each dimension of the variable

Table 2 Demographic description of subjects.

ITEM	CATEGORIES	NUM	PERCENTAGE
GENDER	Male	277	45.86%
	Female	327	54.14%
AGES	18–20	540	89.4%
	21–23	62	10.26%
	> 23	2	0.33%
MAJORS	Science	348	57.62%
	Liberal	221	36.59%
	Arts	33	5.46%
	Sports	2	0.33%
ECONOMICAL LEVEL	Difficult	89	14.90%

was measured by a 5-point Likert scale anchored by: 1-Strongly disagree and 5-Strongly agree.

2.4 Participants

For this study, 604 subjects were selected from two higher education institutes. Their demographic details are presented in Table 2.

2.5 Data Collection and Procedures

Data collection began on September 15, 2023 and ended on October 15, 2023. Prior to the interview phase, the researcher informed participants of the purpose of the interview and asked for their permission to record the session. If the participant chose to continue, he or she firstly completed an information/consent form. Next, the researcher asked for each participant's demographic information such as age, gender, fitness apps usage, and so on. During the interview, each participant was asked questions relating to his/her the level of fitness, sense of gain, mental and physical conditions. Participants could terminate the interview at any time without having to give a reason.

3. RESULTS

In phase 1, the researcher identified several factors that were likely to affect college students' intention to continue using fitness apps. In the interview, the researcher attempted to understand how these factors affect college users' adoption of new technologies and whether there are additional factors that affect their choices and decisions. Based on the questionnaire data and related literature analysis, we discuss whether digital technology can empower the fitness industry via mobile fitness apps from the perspective of Chinese college students. We also explored the macro environment, determine the challenges and shortcomings in the digital transformation of the fitness industry, and propose relevant strategies to promote its intelligent transformation.

3.1 Autonomy Support of Fitness Apps

In the initial stage, we made comparisons to determine whether there is any correlation between gender and willingness to use fitness apps. We conduct a heat map to explore the correlation between "gender" and "whether fitness apps are used". Figure 4 shows the distribution of "gender" and "whether apps are used". Here, fitness app usage is measured on a scale of 1 to 5, where 1 indicates "not used" and 5indicates"Yes and actively used".

Of the female participants, 108 did not use a fitness app (score 1), 99 had unknown app usage (score 3), and 120 used it (score 5). Meanwhile, 123 of the male participants did not use fitness apps (score 1), 68 had unknown app usage (score 3), and 86 used apps (score 5). These statistics indicate that the proportion of female participants using fitness apps is slightly higher than that of male participants.

We chose a second pair of variable groups for a correlation analysis: the use of apps, and exercise habits. The majority of those who do not use apps (60 people who answered "No") think that apps are not effective in promoting sports while only a small number of participants (20 people who answered "yes") think that apps (Help) are effective in promoting sports. The latter group believe that fitness apps are helpful for promoting exercise, about 70people selected "yes", and fewer users think they are not helpful, about 20 people said "yes". 80 people confirmed the fitness apps is unsupported. Table 3 shows that there is a positive correlation between the use of fitness apps and believing that apps encourage exercise. In other words, users who use apps are more likely to believe that apps help facilitate their exercise. However, in order to draw more precise conclusions, a more in-depth statistical analysis is necessary, such as calculating a correlation coefficient or performing a chi-square test

$$\Phi = \frac{(70 \times 80) - (30 \times 20)}{\sqrt{(70+30) \times (20+80) \times (70+20) \times (30+80)}} \tag{1}$$

Cramer's V is a generalized correlation coefficient that measures the strength of the relationship between two categorical variables, with values ranging from 0 (no correlation) to 1 (perfect correlation). In this case, Cramer's V value is close to 0. The Cramer's V correlation coefficient between "Whether APP is used" and "APP promotes exercise" is approximately 0.0362. This data shows that the correlation between "whether app is used" and "app promotes exercise" is weak. This means that although we previously observed a trend from the heat map, the correlation between the two variables is actually not very strong.

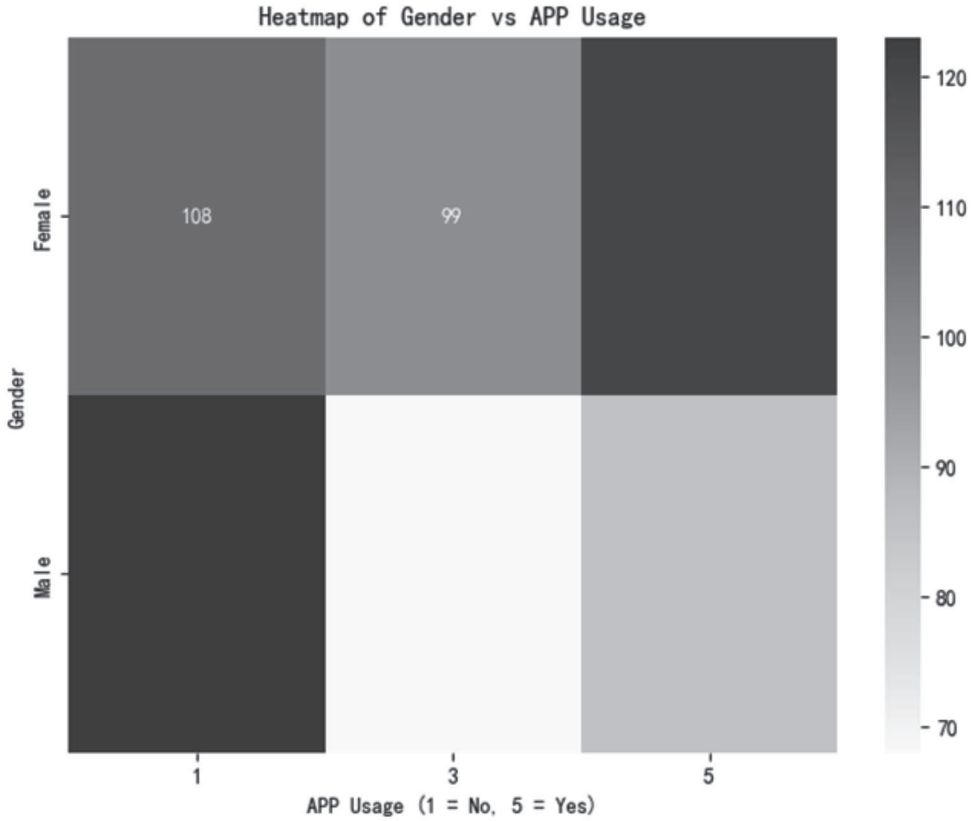

Figure 4 Heat-map of gender VS Apps usage.

Table 3 Correlation analysis between fitness apps support and usage of fitness apps.

Fitness apps support usage of fitness apps	Positive support	No support	Total
Actively using	70	30	100
Never use	20	80	100
Sum	90	110	200

Table 4 Demographic characteristics of participants using fitness Apps(N=10/207).

Participant	Age	Gender	Fitness apps	Usage time (week)	Frequency (week)
P1	19	Male	Keep	4 hours	3
P2	20	Female	Du dong	6	7
P3	21	Male	Keep	5	4
P4	20	Female	Nike training	3	4
P5	23	Male	Du dong	5	5
P6	20	Female	Yue dong quan	4	3
P7	22	Male	Keep	6	4
P8	19	Female	Nike training	4	3
P9	23	Male	Keep	4	6
P10	21	Female	Nike training	3	2

3.2 Reliability and Validity of Fitness Apps

In the middle stage, we randomly selected 10 subjects for interviews.We investigated not only their level of fitness and sense of achievement by using fitness apps, but their personal, independent management of exercise via fitness apps support, as shown in Table 4.

From Table 5 we can see the driving factors (83.64% and 72.70% participants confirmed the ease of use of fitness apps) of digital technology.Readiness had a positive and significant influence on the perceived ease of use and usefulness of mobile fitness apps. Chinese college students' overall consumer fitness concepts and habits are currently being established. The subjects' responses to question 10 and question 11 indicate that more than two thirds of the college students recognize the usefulness of the fitness apps. Another significant result is that health consciousness positively influenced the perceived ease of use and usefulness

Table 5 Experience using mobile fitness apps.

Usage experience	Question items	Ave Scores	Num of subjects	Percentage
Confirmed ease of use	Q10.I learned how to use fitness apps quickly & easily	4.08	490	83.64%
Confirmed usefulness	Q11. Some functions of fitness apps are very practical for me	3.64	434	72.70%
Fitness achievement	Q13.By using fitness apps, I can do aerobic exercise for longer periods of time.	4.59	549	91.96%
Time and frequency	Q12.I use fitness apps more than three days and half an hour each time per week	3.57	421	71.52%
Social connection	Q14. I have a lot of friends on fitness apps	3.84	458	76.71%
Satisfaction	Q15.Overall, I feel very satisfied using fitness apps	4.06	485	81.24%
Continuance to use	Q16.After using it for a while, I continued to use the fitness apps	4.39	525	87.94%

Table 6 Correlation analysis between level of fitness and strength improvements.

Strength enhancing level of fitness via apps	Strength enhanced	Strength not improved	Total
Once a week	40	10	50
More than 2 times	70	20	90
Seldom use	30	50	80
Never use	20	60	80
Sum	160	140	300

of mobile fitness apps. Responses to question 13 and question 16 indicate that over 87.94% of subjects acknowledge the achievement of using a fitness app and are willing to use it in the future. In general, fitness apps have a significant effect on the health and mental well-being of college students.

3.3 Autonomy Management and Achievement of Fitness via Fitness Apps

For another correlation analysis we chose a third pair of variable groups: whether to use an app, and exercise habits. We compared the amount of exercise done by college students using fitness apps every week. The determined the relationship between (exercise amount = intensity * time * frequency) and the physical fitness improvement and aerobic exercise effect on college students. Using the questionnaire survey data, we constructed Table 6 to determine the correlation between the amount of exercise done by college students using fitness apps and their physical fitness and aerobic exercise.

In Table 6, rows represent frequency of use and columns represent strength-enhancing effects. Similarly, we can create a table to represent the effects of aerobic exercise.

Next, we performed a correlation analysis: We calculated Cramer's V coefficient, which is a measure of the strength of association between two nominal variables and is suitable for contingency tables larger than 2x2. We then performed a chi-square test to determine whether there was a statistically significant association between frequency of use and strength gains or cardio improvements.

First, the Cramer's V coefficient was calculated.

$$V = \sqrt{\frac{\chi^2}{n \times \min(r-1, c-1)}} \tag{2}$$

Where $\xi^2$is the chi-square statistic, n is the sample size, r is the number of rows, and c is the number of columns.

Next, we performed a chi-square test. The purpose of the chi-square test is to determine whether the difference between the observed frequency and the expected frequency is significant.

- Chi-square statistic (ξ^2) = 69.75
- p-value: < 0.0001 < 0.0001
- Cramer's V coefficient: approximately 0.482

Result analysis: Chi-square statistic and p-value: The chi-square statistic is approximately 69.75, and the corresponding p-value is much less than 0.05, which indicates that there is a significant statistical association between "weekly frequency of use" and "strength improvement". In other words, the effects of frequency of use and strength improvement are not independent.

Cramer's V coefficient: Cramer's V coefficient is approximately 0.482, which indicates a moderate strength of

association between "weekly frequency of use" and "strength gains." Cramer's V coefficient ranges from 0 to 1, where 1 represents perfect correlation and 0 represents no correlation.

The results are: (1) Most of the subjects (86.52%) admit that digital technology readiness significantly influenced the perceived ease of use and usefulness of mobile fitness apps. (2) Most subjects acknowledged the achievement of using fitness apps and were willing to use it in the future. (3) The majority of students (more than 71.5%) preferred to reduce fitness frequency and longer fitness time, so that the time given to aerobic exercise is gradually reduced. (4) More than half of the participants suggested that fitness apps developers should improve fitness guidance of scientific, professional and targeted training programs.

We used a similar method to analyze the correlation between the amount of exercise done by college students using fitness apps and their aerobic exercise effects. The results are as follows: Chi-square statistic and p-value: The chi-square statistic is 76.80, and the corresponding p-value is much less than 0.05, which shows that there is a significant relationship between "weekly frequency of use" and "aerobic exercise" improvement. In other words, frequency of use is not independent of the effects of aerobic exercise improvement.

Cramer's V coefficient: Cramer's V coefficient is approximately 0.506, which indicates a moderately strong association between frequency of weekly use and improvement in aerobic fitness. Cramer's V coefficient ranges from 0 to 1, where 1 represents perfect correlation and 0 represents no correlation.

In summary, frequency of use has a statistically significant and moderate association with both strength gains and aerobic improvements. This means that frequency of use may be an important factor in determining the effectiveness of exercise.

4. DISCUSSION (STRATEGICAL ANALYSIS OF PESTEL OF CHINA'S LEISURE SPORTS INDUSTRY)

4.1 Policy Analysis of Intelligent Transformation of China's Leisure Sports Industry

The growing sports industry is the inevitable outcome of the mature stage of production and life in modern society and is also an important component of "Five happiness industries". From 2014 to 2022, the State Council issued a series of policy documents to promote the development of the sports industry and encourage people to "spare time and bring money" on fitness activities, and to participate in fitness, leisure and consumption. According to the data provided by the provinces, the goal is to reach 7 trillion yuan. At the same time, it was proposed that national fitness become a national strategy. In addition to policies at the national level, the National Bureau of Statistics has also included the sports industry as a key inspection industry.

In 2016, the National Fitness Plan (2016–2020), the 13th Five-Year Plan for Sports Development, and the Outline of the 2030 Plan for Healthy China were published. Three years later, the State Council issued the Notice on the Issuance of the Outline of the Construction of Sports Power, indicating that the sports industry would become a pillar industry of the national economy by 2035.

However, the contribution of the sports industry to the development of our national economy is still relatively low for various reasons. In developed countries, it is generally between 2% and 3%, among which the annual output value of sports industry in the United States accounts for 3% of GDP. In 2016, the General Administration of Sport made it clear that the sports industry contribution to the GDP should reach 1% during the 13th Five-Year Plan period. China has taken the lead in achieving this goal, but it is still far behind that of developed countries [19]. At present, the status of the sports industry in our country is still quite unstable. The material living standards of the population have been improving year by year, but the amount of participation in sports consumption has not been substantially improved. This situation deserves the attention of researchers and the relevant government departments.

4.2 Social Environment Analysis of Intelligent Transformation of China's Physical Fitness Industry

In the past few years, an increasing number of commercial fitness equipment has been designed for home applications and outfitted with smart technology, especially during the epidemic, and this has resulted in the family fitness equipment market growing rapidly both at home and abroad. According to the per capita consumption expenditure of Chinese residents, in addition to the expenditure on housing, food, tobacco, alcohol, and transportation and communication, the expenditure on education, culture and entertainment accounted for a relatively high proportion and showed a further trend of increase. In 2019, the proportion of the expenditure on education, culture and entertainment was 11.7%, far exceeding the expenditure on health care, daily necessities and services, clothing and other fields. Chinese residents pay more attention to education, culture and entertainment, and radriate the development of Chinese children's sports training and other related industries. Fitness app users can easily obtain training tips, find online fitness courses, and get connected with other fitness enthusiasts and professional trainers via their smart phones.

4.3 Economical analysis of Intelligent Transformation of China's Physical Fitness Industry

The COVID-19 pandemic caused large-scale business closures in China, so it comes as no surprise that physical fitness clubs have been struggling to survive ever since. Furthermore, the trend for home exercise accelerated during the lockdown periods was very likely to continue after the pandemic, posting a long-term challenge for physical gyms. Sports apps such as Keep, Codoon, and Mi Fit have been well-received among millions of online fitness users in China. Figure 3 shows that since 2015, the total output value of sports industry has

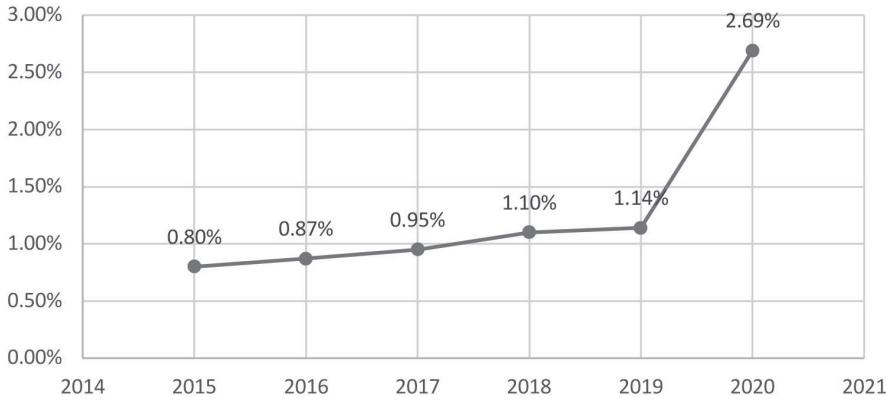

Figure 5 The total output value of sports industry (Year 2015–2020).

Table 7 Comparison of fitness industry scale between China and U.S.A and several European countries.

Region	Fitness clubs	Fitness population (million)	Country's population (million)	Fitness population penetration
Mainland China	49,860	68.12	1,395	4.90%
Hong Kong, China	980	0.51	7.42	6.80%
U.S.A.	39,570	62.50	327	20.30%
Germany	9,343	11.09	82.93	13.40%
Italy	7,700	5.46	60.43	9.00%
United Kingdom	7,038	9.90	66.49	14.90%
France	4,370	5.96	66.99	8.90%

been increasing as a proportion of the GDP, and the booming development of sports industry has made a great contribution to the country's economic growth. According to statistics, the total expenditures of China's sports industry accounted for 2.69% of the GDP in 2020.

Regardless of whether a fitness product is targeted at youths, the elderly, or the general population, the trend is clear: fitness services must reflect the clients' wider social needs, requiring a strategic market-tested approach to strengthen competitiveness.

Figure 5 shows that in the United States and France, the sports industry accounts for more than 2.5% of GDP, and the global average is 2.1%. Table 7 shows us that in 2020, about 68.12 million people were involved in some way in China's fitness industry, which is higher than that in the U.S.A in terms of the absolute number of members. However, this constitutes only 4.9% of China's total population of 1.395 billion, indicating a relatively low level of penetration. In the U.S.A, this rate is 20.3%, which is 4.1 times higher than China's. The Europe's average rate is 10.1%, which is 2.1 times higher than China's. At present, China's sports industry development is not balanced, and the sports industry in terms of GDP contribution is smaller than the world average, with the leisure sports industry in particular being even smaller.

4.4 Technical Analysis of Intelligent Transformation of China's Physical Fitness Industry

The fitness trend has become increasingly popular because of the internet, particularly among the younger generation. Riding on the trend of health and wellness aligned with rising incomes, fitness KOLs are emerging and playing an increasingly crucial role in influencing millennial and gen *Z* towards a healthy lifestyle. Although the technological environment of Chinese sports industry has been greatly improved, it is still in the stage of extensive development. Furthermore, the basic research is still weak, and there is a lack of systematic and sustainable sports science and technology planning [20].In the coming few years, technology will continue to reshape China's fitness market. Fitness studios with high-tech apparatus are expected to be more competitive in the market, while less qualified trainers will face pressure from their customers who can obtain professional information from various online channels. In addition, the consumption of high-tech sportswear and wearable devices is projected to rise. Market observers predict that the fitness industry in China will integrate online services and offline operations to provide more personalized, convenient, and goal-oriented offers.

Catalyzed by the pandemic, Chinese adolescents' awareness of physical fitness has increased rapidly, with the government's comprehensive support for the intelligent transformation of physical fitness industry, huge business space and large sports and fitness market are emerging. According to the Zhang et al. experimental study, there is a big development opportunity for college students in the fitness industry [21]. From the macro and micro analysis of Chinese physical fitness industry, these findings determined that the most important micro factors of the intelligent transformation of physical fitness industry are the driving factors of technology readiness, health consciousness, and customer-oriented usage of the mobile fitness apps. The macro factors include political

support, economic transition, social fitness awareness, digital technology empowerment and legal regulation for the physical fitness industry.

5. CONCLUSION

This paper proposes four strategies to improve and promote the intelligent development of fitness sports. First, make full use to digital technology to broaden the range and reach of the fitness industry. Increase financial investment in the development of smart sports, and encourage outstanding sports companies to participate in the research and development of smart sports products. Promote the establishment of smart sports think tanks, further consolidate the basic theory of smart sports, and provide intellectual support for the formulation of smart sports development policies. China's various fitness plans and regulations emphasize factors like universal access and the relationship between physical activity and health care concerns. With these elements in mind, there is an especially significant push to engage youths and the elderly with fitness.

Secondly, take the advantage of digital technology to develop a client-centered fitness approach under the guiding "Common Prosperity" policy, the Chinese government is prioritizing health and quality of life issues. One of the reasons that Chinese regulators have put restrictions on private tutoring, excessive homework, and video game usage is the hope that these regulations will encourage youths to spend more time on physical activity. Engaging youths in physical activity can be challenging, however, especially for those living in dense urban environments without sufficient public sports infrastructure. To navigate these challenges, service providers can offer team-oriented social communities and app-based gamification that integrate online and offline fitness experiences [22, 23]. These principles are integral to Keep, one of the most successful fitness apps in the Chinese market. In future, if fitness centers aim to expand, then they must allow their users to share their workouts on social media accounts and connect e-fitness trends with their traditional brand to satisfy customer needs.

Thirdly, the physical fitness industry should take "quality change, efficiency change, power change" as its main development path. Basically,it should strive to form a consumption-led, innovation-driven, active subject, and better-structured development pattern by 2025. Furthermore, it will achieve comprehensive and high-quality development and become a major industry and pillar of the national economy by 2035.

In the context of digitization economy development, the development opportunities of the leisure sports industry should be seen from three perspectives: (1) information technology promotes the leisure sports industry to seize opportunities to expand the market; (2) information technology innovates the management mode of the leisure sports industry and operation mode; (3) information technology transforms the leisure sports industry service platform and physical fitness industry. The structural change in the development of the leisure sports industry is reflected in the transformation of the new competition system, new technology system and new consumption structure [24–26]. In the context of digital economy and high-quality development policies, we need to analyze more deeply the opportunities and challenges that the physical fitness industry faces and propose more specific operational strategies to build a novel physical fitness industry ecosystem and business model to promote its healthy development. The government and other social entities should develop relevant policies, systems, laws, and regulations and create a high-quality environment ruled by law for the leisure and fitness sports industry. In order to promote the rapid development of China's leisure sports industry and sports consumption market, the government strategy for national fitness should be reviewed, and the important promotion role of national fitness should be paid attention to, and the national fitness should be actively publicized so that everyone can achieve the intelligent transition of the physical fitness industry [27–29].

The main limitations of this study are: (1) Not all the participants surveyed were represented in our interviews; this is important since the variables of age and gender are the most influential factors. (2) Due to the complexity of the subjects, the majority of the participants were non-P.E. students who may not have the same willingness to use the physical fitness apps. (3) Due to time constraints for the experiment and the sample number, this study's qualitative results were obtained from the data of only 10 interviewees, and the quantitative results were based on fewer than 600 online questionnaires. Thus, a more comprehensive range of age groups and a larger number of participants should be used insubsequent studies.

DATA AVAILABILITY

The datasets analyzed in the current study are not publicly available because they contain non-public data but are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

Conceptualization, Hua Wei; Methodology, Deng Pan; Software, Deng Pan; Validation, Deng Pan and Hua Wei; Formal analysis investigation, Deng Pan and Junxiang Xiao; Resources, Junxiang Xiao; Data curation, Deng Pan; Writing: original draft preparation, Deng Pan; Writing: review and editing, Hua Wei; Visualization, Supervision, Junxiang Xiao; Project administration, Deng Pan. All authors have read and agreed to the published version of the manuscript.

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None

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Hubei University of Science and Technology (protocol code: 0228/2023 and date of approval: 28 February 2023).

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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