Comparing Sports IoT Healthcare Devices and e-Health Literacy and Awareness among College Students: Pre-and Post-COVID-19 Perspectives

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Abstract

This study investigated the difference between sports major college students' perception of using IoT healthcare devices and e-health literacy before and after COVID-19. A quantitative research questionnaire was distributed randomly among 600 sports college students majoring in sports in metropolitan and non-metropolitan universities in Korea. The study's findings show a significant difference in perception of using IoT healthcare devices and e-health literacy before and after COVID-19. Secondly, before COVID-19, the perception of the use of IoT healthcare devices showed significant differences by grade. On the other hand, functional e-health literacy, communication e-health literacy, and critical e-health literacy showed significant differences by grade. Third, there was no significant difference in perception of the use of IoT healthcare devices by grade after COVID-19. Conversely, functional e-health literacy, communication e-health literacy, and critical e-health literacy showed significant differences by grade. Fourth, before COVID-19, there were statistically significant differences in perceptions of using IoT healthcare devices in local cars. However, there was no statistically significant difference in terms of e-health literacy. Fifth, there was no statistically significant difference in regional differences between the metropolitan and non-metropolitan areas after COVID-19. This study showed the differences between COVID-19 and after COVID-19 by comparing the high level of awareness of using IoT healthcare devices and e-health literacy of sports college students, which will foster talented people who can demonstrate professionalism in the sports field.

Keywords: Sports, IoT Healthcare Device, e-Health Literacy, College Student, COVID-19

1.0 Introduction

Modern society, which is recently called the era of the fourth industrial revolution, is an era in which new values are created in a convergent environment without boundaries between information and communication technology and industrial technology. In addition, the prolongation of life expectancy and the ageing of the population after the COVID-19 outbreak and advances in medical technology have significantly impacted people's awareness and approaches to health and sports traditional medical care (Abdullah et al., 2016; Jeyakumar, Nirmala, & Nithya, 2022). Sports among the adult generation, as the main focus of treatment in medical institutions and hospitals, is no longer the best option for people who want to live long, healthy lives while enhancing their quality of life. Instead, they are turning to services that can prevent diseases and manage factors that affect health. Healthcare and sports integrated with information and communication technology and artificial intelligence, this widespread interest and demand have enhanced accessibility through healthcare (Wang et al., 2023). There were high hopes for the value of the growth of the healthcare sector. Many countries worldwide are creating a new sports welfare paradigm to enhance people's health by lowering medical costs by investing a lot of money in sports welfare, such as making it simple to utilize IoT healthcare devices in the wake of the recent COVID-19. With all this, the foundation of life sports is growing (López-Valenciano et al., 2021).

With the emergence of the Internet of Things (IoT) and its convergence with the healthcare industry, this sector is attracting increased government and private attention. IoT healthcare technology, services, and markets have expanded quickly, propelling the IoT healthcare industry to become a next-generation blue ocean. The Internet of Things (IoT) can increase access to healthcare for healthcare users and reduce service costs for operators. Global information and communication technology companies such as Google, Apple, and Samsung, as well as sports-related companies, are trying to preoccupy new markets by launching various healthcare devices. Recently, with the growing interest in health due to the spread of COVID-19 and the increase in demand for non-face-to-face services, IoT healthcare is a way to overcome temporal and spatial constraints using applications and solve the problem of lack of exercise in modern people (Senbekov et al., 2020). Through the advancement of smartphones and Internet connection technologies, the majority of IoT healthcare devices forecast that, between 2020 and 2025, when the COVID-19 pandemic occurred, the number of interconnections between various devices will rise to more than 25 billion (Dinh C Nguyen et al., 2021).

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Therefore, as more and more people and things are connected, the amount of data exchanged between them will grow unimaginably. As a result of this interconnection, new or advanced IoT healthcare devices will be used to develop services related to sports and health. The IoT is creating new areas in the sports industry for health promotion by providing innovative ways to effectively connect things-to-things (M2M), people-to-things (M2M), and people-to-people (P2P) (Ahmad et al., 2019; Eskofier et al., 2017; Ullah et al., 2020).

The continuous increase in the number of people actively searching for and using health information through the Internet and mobile devices such as smartphones is increasing information and communication technologies to provide health information online and measure health risks to manage chronic diseases. In addition, e-health literacy emerged as the ability to seek, search, understand, and evaluate health information online and to apply and transmit the acquired knowledge to deal with and solve health problems (Loer et al., 2022). The greatest strength of this e-health literacy is that active users who voluntarily search for necessary health information can use health information quickly and efficiently to have healthcare habits to prevent diseases in advance and be engaged in sports (Chen et al., 2023; Lodangco, 2023; Norman & Skinner, 2006). A survey study conducted in Korea shows that with COVID-19, 97.6% of the general public and 99.9% of university students in their 20s utilize the Internet. Internet use and dependence are expected to increase in society (Kim, 2012; Yousaf et al., 2023). Therefore, if the level of e-health literacy of college students majoring in sports is improved, they will be able to demonstrate professionalism for users who want to effectively use health information online after graduating from college. In this study, the following were considered. How does the awareness of using IoT healthcare devices and e-health literacy of college students majoring in sports differ before and after COVID-19, and by grade and region? The study aims to investigate the differences in college students majoring in sports' awareness of and attitudes towards IoT healthcare devices and e-health literacy before and after COVID-19 and to identify the factors associated with higher levels of these variables.

2.0 Literature Review

Sports are a field that forms a physically, mentally, and socially intact human being through physical activity. of sports. Also, recently, sports engineering, which can utilize and develop equipment necessary to improve performance in sports or to promote health through exercise by using engineering principles, is expanding the field of study in sports majors. This is a field to solve the problems of motion and mechanics related to sports and equipment, and it has made it possible to learn and enjoy sports quickly and safely, not only for sports players but also in life sports (Woods et al., 2020). Starting with COVID-19, it is possible to recognize sports or health conditions or behaviours for physical fitness through a healthcare device combined with the Internet of Things. In healthcare, more attention has been paid to accurately monitoring and analyzing human health status factors. The high-performance microcontroller embedded in the sensors of these IoT healthcare devices can accurately measure various elements from objects or people. In particular, wearable healthcare devices are connected to users in the virtual world of the Internet of Things (IoT), where people, objects, and spaces are connected, which is very useful in managing health and enhancing physical strength.

Through IoT healthcare devices in various sports, body data such as heart rate, energy consumption, exercise amount, exercise time, distance travelled, and respiration rate are collected and analyzed. Collecting and analyzing the biometric information of athletes and sports players can improve performance while maintaining health, especially when exposed to environmental risks. In addition, even individuals who participate in physical sports can identify abnormal body indicators and measure their sporting prowess through monitoring and analyzing exercise when the line between exercise continuation and rest is unclear. There is a great risk of harming their health. It can increase your motivation to exercise. Moreover, the accumulated data on the body can help determine whether or not the person is infected with the COVID-19 virus, which can help people lead healthy lives (Song & Sun, 2023).

Wearable healthcare devices are the most actively applied IoT healthcare devices in daily life, and healthcare services that make use of them are also widely applied. After the COVID-19 period, various related services that can manage factors affecting health, such as exercise, sleep, and diet through smartphone applications, are being provided more and more actively. As a result, students majoring in sports should be interested in, understand, and employ IoT healthcare devices, which have been used more frequently since COVID-19, when providing services to those who want to practice and learn sports. Hence, one must be aware of whether or not it helps when using it.

On the other hand, With the enforcement of related laws, such as the Framework Act on Sports in 2021, participation in sports is allowed in Korea, laying the institutional foundation for advanced sports countries (Xiao, 2022). In addition, improving e-health literacy is connected with the social trend that aims to lead a mentally and physically healthy and comfortable life by balancing the body and mind after COVID-19. This means we can change new information while communicating with you appropriately. It should be critically analyzed or utilized while applied to the context in which it is used. It can adapt and overcome unexpected viruses and diseases such as COVID-19 healthily (Wang, Wu, & Qi, 2021). The World Health Organization (WHO) has defined health literacy as a cognitive and social technology based on the ability and motivation to access, understand and use information or maintain and promote health. Moreover, the European Union defines health information as the ability to read, understand and screen health information for appropriate decision-making. In other words, health literacy is distinct from general literacy in reading, writing, and speaking in that it refers to the ability to read and understand basic health information and health-related data required to make informed decisions about one's physical activity and health, as well as to develop healthy behaviours as a result. However, as the use of the Internet increases, e-health literacy is the ability to use information and communication technology to measure health status as a concept added to digital literacy and achieve health behaviour changes through health promotion and monitoring and management of chronic diseases (Keshkar et al., 2021). The general public reported knowing how to obtain information online, find health information, or apply knowledge and information online to decide on health status. Knowledge of whether or not health resources are available and which health resources are available could be higher. In addition, the information on the Internet can be rife with information that needs more expertise, and due to the nature of the Internet, there is no way to properly control it (Alonso, de la Torre Díez, & Zapiraín, 2019). Therefore, a college system that can utilize accurate health information through healthy living and sports should be conducted. The awareness of the importance of e-health literacy by college students majoring in sports is essential for athletes participating in sports and general people who engage in physical education.

It is also divided into e-health literacy and critical e-health literacy, which are advanced cognitive abilities to use relevant health information while critically analyzing and controlling situations occurring on the Internet. E-health literacy is a functional e-health literacy that means people can understand health knowledge and information acquired from the Internet (Liang et al., 2022). Many studies related to e-health literacy found that the higher the e-health literacy of college students and the higher the grade, the higher the level of health awareness (Alonso et al., 2019). However, studies have yet to be conducted on how these characteristics of college students have changed since COVID-19.

The utilization and utility of IoT healthcare devices are improved, and the need for college students majoring in sports who are cultivating professional capabilities in health and physical education to be aware of these aspects is increasing. Meanwhile, as the world experiences COVID-19, interest in health and exercise has increased, and online activities to actively search for health and exercise-related information have increased. Health literacy is lacking, the understanding of medical knowledge and information is lowered, and as self-reporting about diseases is delayed, the individual's health condition deteriorates, leading to increased medical expenses (Ghimire et al., 2020).

3.0 Research Method

A quantitative study by nature was conducted, and questionnaire survey data were collected from the college students majoring in sports at four-year colleges located in the metropolitan and non-metropolitan areas to respond to the test in November 2019 before COVID-19 and in November 2021 after COVID-19. Questionnaires were randomly distributed among 600 students in the metropolitan area, and about 512 respondents answered the questionnaire. All tests were conducted anonymously and based on the test results answered to all questions, an independent sample t-test, one-way analysis of variance (ANOVA) was performed using SPSS 25.0 for 512 data before COVID-19 and 515 data after COVID-19 and post-validation Scheffé were performed to analyze the data.

4.0 Results and Discussion

Table 1 shows the demographic characteristics of college students majoring in sports in metropolitan and non-metropolitan universities. Data were collected before COVID-19 and post covid year 2021. Demographic characteristics show that almost equal distribution found in the gender response for pre-covid, about 52.1% were male, and post-covid, 49.3 % were male respondents, and they are different years of university students.

Table 1

Research subject: Before COVID-19

Division		Pre-Covid-2019		Post Covid-Year 2021	
		Frequency	Percentage	Frequency	Percentage
Gender	Male	267	52.1	254	49.3
	Female	245	47.9	261	50.7
Grade	1	148	28.9	148	28.7
	2	117	22.9	123	23.9
	3	121	23.6	113	21.9
	4	126	24.6	131	25.4
Region	Non-metropolitan	278	54.3	224	43.5
	Metropolitan	234	45.7	291	56.5
Total		512	100.0		515

4.1 Awareness of IoT Healthcare Devices

The IoT healthcare device utilization awareness test was composed mainly of what the sports related IoT healthcare device utilization should be aimed at to investigate the awareness of college students majoring in sports. It was composed based on various previous studies, such as Huifeng, Kadry, and Raj (2020), and three experts also verified (Ridwan, Sholikhah, & Prakoso, 2022) and content validity. A total of 8 items, each item on a Likert 5-point scale (1 point not at all to 5 points strongly agree). The reliability (Cronbach's α) of the overall test tool in this test is.921. The test configuration is presented in Table 2.

Table 2

Awareness of healthcare device

Itemized	Number	Cronbach's α
Understanding of IoT healthcare device utilization	2	.959
The need for IoT healthcare device utilization	2	.924
Interest in IoT healthcare device utilization	2	.918
Whether IoT healthcare device utilization is helpful for daily life or not	2	.912
Total	8	.921

4.2 E-Health Literacy

The e-health literacy test tool was developed and validated for adults including college students (Harper, 2014; Hong et al., 2021). Each item is a Likert 5-point scale (1 point not at all to 5 points strongly agree). The reliability of this test was found to be Cronbach's α.942, and the details of the test tool are presented in Table 3.

Table 3

E-Health Literacy

Item	Number	Cronbach's α
Functional e-health literacy	8	.921
Communicative e-health literacy	11	.963
Critical e-health literacy	2	.955
Total	31	.942

4.3 Differences in the Awareness of IoT Healthcare Device and e-Health Literacy before and after COVID-19

The results of analyzing the difference in the awareness of IoT healthcare device utilization and e-healthcare literacy before and after COVID-19 were as follows. It is presented in the following Table 4 and Table 5.

There was a statistically significant difference in understanding, necessity, interest, and whether or not it was helpful for daily life and total of utilizing IoT healthcare devices before COVID-19 ($p<.05$). In particular, the level of understanding and interest in IoT healthcare devices showed an average score of close to 4 from the early 3 points after COVID-19. In addition, as to whether using IoT healthcare devices is helpful for daily life, the average score exceeded 4 points after COVID-19, and as the use of IoT healthcare devices increases due to the COVID-19 situation, various help can be provided in daily life. The level of awareness of IoT healthcare device utilization was higher after COVID-19 than before, and the difference was statistically significant ($p<.05$).

Table 4

Difference in the awareness of IoT healthcare device utilization before and after COVID-19

Sub-factor	Classification	N	M	SD	t	p
Understanding of IoT healthcare device utilization	Before COVID-19	512	3.33	1.54	-5.616	.000
	After COVID-19	515	3.86	1.48		
The need for IoT healthcare device utilization	Before COVID-19	512	3.60	1.38	-3.452	.001
	After COVID-19	515	3.91	1.55		
Interest in IoT healthcare device utilization	Before COVID-19	512	3.29	1.72	-7.025	.000
	After COVID-19	515	3.98	1.43		
Whether IoT healthcare device utilization is helpful for daily life	Before COVID-19	512	3.51	1.61	-7.302	.000
	After COVID-19	515	4.18	1.32		
Awareness of IoT healthcare device utilization	Before COVID-19	512	3.43	1.17	-7.575	.000
	After COVID-19	515	3.98	1.17		

Table 5 shows that functional e-health literacy before COVID-19 had an average score of 3 points, but after COVID-19, the average score exceeded 4 points. The difference was statistically significant (p<.05). This is COVID-19, isolated from work and school, and the use of health information on the Internet using a computer or mobile device at home has increased. The level of reading and writing has increased. In addition, there was a statistically significant difference in the total of communicative and critical e-health literacy and e-health literacy when comparing pre-COVID-19 and post-COVID-19 (p<.05). Therefore, compared to before COVID-19, after the outbreak of COVID-19, college students majoring in sports actively access and acquire information related to exercise and health using the Internet about their major, and the level of e-health literacy has increased.

Table 5

Difference in the awareness of e-health literacy before and after COVID-19

Sub-factor	Classification	N	M	SD	t	p
Functional e-health literacy	Before COVID-19	512	3.32	1.75	-9.299	.000
	After COVID-19	515	4.11	0.79		
Communicative e-health literacy	Before COVID-19	512	3.45	1.47	-3.765	.000
	After COVID-19	515	3.83	1.68		
Critical e-health literacy	Before COVID-19	512	3.25	1.46	-5.631	.000
	After COVID-19	515	3.79	1.59		
e-Health literacy	Before COVID-19	512	3.34	1.36	-7.653	.000
	After COVID-19	515	3.91	0.98		

4.4 Differences by Grade in the Awareness of IoT Healthcare Device Utilization Before COVID-19

The differences by grade in the awareness of IoT healthcare device utilization before COVID-19 were analyzed as follows. It is presented in the following Table 6 and Table 7.

In terms of understanding, necessity, interest, and whether IoT healthcare device utilization is helpful for daily life, the upper grades of grades 3 and 4 were higher than that of the lower grades of grades 1 and 2. The difference was statistically significant (p<.05). Before COVID-19, first-year students recognized the understanding and necessity of using IoT healthcare devices at an average level. However, considering that interest was shown in the late second point, they took enough exercise and health-related significant classes. Interest in such primary knowledge seemed lower than that of other grades. On the other hand, the average score of 4th graders on the need for the use of IoT healthcare devices was more than 4 points, which was to understand the relationship between health and physical activity and to provide knowledge and information about sports activities for health promotion. It is interpreted that the awareness level of the 4th graders, who are in the upper grades, is higher than that of the lower grades about the need for the latest methods that can be used. On the other hand, the total awareness of IoT healthcare device utilization was averaged at 3.43, which needs to be higher.

Table 6

Awareness of IoT healthcare device utilization before COVID-19 by grade: Descriptive statistics

Grade	Understanding of IoT healthcare device utilization		The need for IoT healthcare device utilization		Interest in IoT healthcare device utilization		Whether IoT healthcare device utilization is helpful for daily life		Awareness of IoT healthcare device utilization	
	M	SD	M	SD	M	SD	M	SD	M	SD
1	3.07	1.61	3.21	1.42	2.92	1.70	3.19	1.62	3.10	1.10
2	3.17	1.55	3.31	1.36	3.09	1.75	3.27	1.71	3.21	1.19
3	3.52	1.48	3.79	1.28	3.48	1.69	3.65	1.57	3.61	1.17
4	3.71	1.39	4.02	1.32	3.73	1.64	3.96	1.45	3.85	1.07
Total	3.36	1.54	3.58	1.38	3.30	1.72	3.51	1.61	3.43	1.17

Table 7

Awareness of IoT healthcare device utilization by grade before COVID-19: One-Way ANOVA

Sub-factor		SS	df	MS	F	p	Scheffé
Understanding of IoT healthcare device utilization	Inter-group	40.182	3	13.394	5.834	.001	Four>1,2,3
	Within-group	1166.290	508	2.296			
	Total	1206.472	511				
The need for IoT healthcare device utilization	Inter-group	48.689	3	16.230	8.933	.000	3,4 >1,2
	Within-group	922.928	508	1.817			
	Total	971.617	511				
Interest in IoT healthcare device utilization	Inter-group	53.382	3	17.794	6.203	.000	3,4 >1,2
	Within-group	1457.337	508	2.869			
	Total	1510.719	511				
Whether IoT healthcare device utilization is helpful for daily life	Inter-group	49.028	3	16.343	6.474	.000	4 >1,2,3
	Within-group	1282.441	508	2.524			
	Total	1331.469	511				
Awareness of IoT healthcare device utilization	Inter-group	47.325	3	15.775	12.333	.000	3,4 >1,2
	Within-group	649.753	508	1.279			
	Total	697.078	511				

4.5 Differences by Grade in e-Health Literacy Before COVID-19

Table 8 and Table 9 show that in the first year, the average score of functional and communication e-health literacy and e-health literacy did not reach the average level of 3, and there were statistically significant differences between all lower classes and other grades in the entire e-health literacy ($p<.05$). In particular, in communicative e-health literacy, the difference with the 2nd, 3rd and 4th graders was statistically significant, which seemed to be relatively fewer opportunities to exchange opinions with others. On the other hand, the average score of e-health literacy increased as they progressed to the upper grades 3 and 4, and the reason why the level of functional and critical e-health literacy was relatively high was that students took significant subjects related to physical activity and sports. It is interpreted that this is because there are more cases of making decisions using health information found on the Internet to practice physical health while taking classes compared to other grades. In addition, while majoring in sports at a college, it is because the communication part is more active in practising an exercise plan, receiving online management to automatically check the health of the body, expressing my opinion about health and asking related questions.

Table 8

E-Health literacy by grade before COVID-19: Descriptive statistics

Grade	Functional e-health literacy		Communicative e-health literacy		Critical e-health literacy		e-Health literacy	
	M	SD	M	SD	M	SD	M	SD
1	2.90	1.43	2.83	1.37	3.07	1.74	2.93	1.17
2	3.49	1.35	3.29	1.37	3.11	1.73	3.29	1.27
3	3.71	1.67	3.30	1.68	3.44	1.80	3.48	1.58
4	3.83	1.23	3.65	1.32	3.72	1.65	3.73	1.29
Total	3.45	1.47	3.25	1.46	3.32	1.75	3.34	1.36

Table 9

E-Health literacy by grade before COVID-19: One-Way ANOVA

Sub-factor		SS	df	MS	F	p	Scheffé
Functional e-health literacy	Inter-group	35.923	3	11.974	3.999	.008	3,4 >1,2
	Within-group	1520.978	508	2.994			
	Total	1556.901	511				
Communicative e-health literacy	Inter-group	70.520	3	23.507	11.537	.000	2,3,4 >1
	Within-group	1035.041	508	2.037			
	Total	1105.562	511				
Critical e-health literacy	Inter-group	47.548	3	15.849	7.677	.000	3,4 >1,2
	Within-group	1048.839	508	2.065			
	Total	1096.387	511				
e-Health literacy	Inter-group	46.649	3	15.550	8.811	.000	3,4 >1,2
	Within-group	896.549	508	1.765			
	Total	943.199	511				

4.6 Differences by Grade in the Awareness of IoT Healthcare Device Utilization and e-Health Literacy After COVID-19

Tables 10 and 11 show that the awareness levels for using IoT healthcare devices increased post-COVID-19 than before-COVID-19 in all grade levels. Accordingly, before COVID-19, there was a statistically significant difference between grades in both sub-factors and total IoT healthcare device utilization ($p<.05$). After COVID-19, the average score for each grade was higher than before COVID-19, There was no significant difference between the grades ($p>.05$), and in particular, in the case of upper grades 3 and 4, the average score was 4.05 and 4.30, which is four or more. On the other hand, the level of interest in using IoT healthcare devices for first-year students was 2.92, which was lower than the normal level, but after COVID-19, it was 3.84. This means that all personal data such as meal amount, exercise amount, blood pressure, and mood change generated through smart devices and sensor technology are quantitatively quantified to manage health and protect against coronavirus while students majoring in sports experience COVID-19. To avoid getting caught, it is essential to understand interest, necessity, and whether it is helpful in daily life because activities such as developing physical strength through physical activity while making a diagnosis outside of a medical institution are carried out through IoT healthcare devices. The level of awareness of the subject increased, and as a result, there was no statistically significant difference between the grade groups ($p>.05$).

Table 10

Awareness of IoT healthcare device utilization after COVID-19 by grade

Grade	Understanding of IoT healthcare device utilization		The need for IoT healthcare device utilization		Interest in IoT healthcare device utilization		Whether IoT healthcare device utilization is helpful for daily life		Awareness of IoT healthcare device utilization	
	M	SD	M	SD	M	SD	M	SD	M	SD
1	3.85	1.40	3.73	1.54	3.84	1.51	3.95	1.42	3.84	1.29
2	3.65	1.66	3.75	1.71	3.90	1.37	4.15	1.05	3.86	1.20
3	3.99	1.47	3.98	1.43	3.95	1.47	4.31	1.50	4.05	1.08
4	3.97	1.39	4.26	1.45	4.25	1.34	4.34	1.21	4.20	1.05
Total	3.86	1.48	3.93	1.55	3.98	1.43	4.18	1.32	3.98	1.17

Table 11

Awareness of IoT healthcare device utilization by grade after COVID-19

Grade	Functional e-health literacy		Communicative e-health literacy		Critical e-health literacy		e-Health literacy	
	M	SD	M	SD	M	SD	M	SD
1	4.05	0.67	3.57	1.92	3.51	1.87	3.71	1.15
2	4.07	1.11	3.78	1.69	3.69	1.86	3.85	0.95
3	4.10	0.42	3.83	1.83	3.73	1.34	3.89	0.96
4	4.23	0.80	4.15	1.12	4.24	1.01	4.21	0.70
Total	4.11	0.79	3.83	1.68	3.79	1.59	3.91	0.98

4.7 Differences by Grade in e-Health Literacy after COVID-19

Table 12 and Table 13 show that the functional e-health literacy of the 1st graders was below the average level, with an average score of 2.90 before COVID-19. However, after COVID-19, the average score was 4.05, showing the most significant difference among all grades starting with COVID-19. Also, there was no statistically significant difference between the grade groups in functional e-health literacy ($p>.05$), which seems to be that after the outbreak of COVID-19, 1st graders experienced non-face-to-face classes at their college and had many experiences finding sports programs or information for themselves and found the information they needed in a short time while living a limited life at home or in an isolated place. This is because the level of e-health literacy in first-year college students before COVID-19 was below the average level of 3, but based on the results that appeared in the late 3-point range after COVID-19, the improvement in the level of functional e-health literacy is closely related to the outbreak of COVID-19 whose correlation can be inferred.

Functional e-health literacy is an essential aspect of e-health literacy. It includes both the technical aspects related to the use of the Internet and the practical aspects related to the contents provided by the Internet. Accordingly, the difference in the improvement of functional e-health literacy of first-year college students majoring in sports before COVID-19 and after COVID-19 was the largest. The average score of functional e-health literacy among the sub-factors of e-health literacy was the highest at 4.11. Based on these results, it can be inferred that the improvement in the level of functional e-health literacy is closely related to COVID-19. On the other hand, it was found that the level of all sub-factors and total of e-health literacy improved as the college grade went up, in which there were statistical differences ($p<.05$).

Table 12

E-Health literacy by grade after COVID-19

Grade	Functional e-health literacy		Communicative e-health literacy		Critical e-health literacy		e-Health literacy	
	M	SD	M	SD	M	SD	M	SD
1	4.05	0.67	3.57	1.92	3.51	1.87	3.71	1.15
2	4.07	1.11	3.78	1.69	3.69	1.86	3.85	0.95
3	4.10	0.42	3.83	1.83	3.73	1.34	3.89	0.96
4	4.23	0.80	4.15	1.12	4.24	1.01	4.21	0.70
Total	4.11	0.79	3.83	1.68	3.79	1.59	3.91	0.98

Table 13

E-Health literacy by grade after COVID-19: One-Way ANOVA

Sub-factor		SS	df	MS	F	p	Scheffé
Functional e-health literacy	Inter-group	2.546	3	.849	1.358	.255	
	Within-group	319.443	511	.625			
	Total	321.989	514				
Communicative e-health literacy	Inter-group	24.318	3	8.106	2.894	.035	
	Within-group	1431.432	511	2.801			2,3,4 >1
	Total	1455.750	514				
Critical e-health literacy	Inter-group	40.036	3	13.345	5.390	.001	
	Within-group	1265.308	511	2.476			4 >1,2,3
	Total	1305.344	514				
e-Health literacy	Inter-group	18.142	3	6.047	6.530	.000	
	Within-group	473.242	511	.926			3,4 >1,2
	Total	491.384	514				

4.8 Differences by Region in the Awareness of IoT Healthcare Device Utilization Before COVID-19

Table 14 compares the difference in the awareness of IoT healthcare devices in metropolitan and non-metropolitan areas before COVID-19. The average score of the metropolitan area was higher than that of the non-metropolitan area. There were statistically significant differences in understanding, necessity, interest, and whether or not to use IoT healthcare

devices for daily life. The sum of awareness($p<.05$). Regarding understanding and interest in using IoT healthcare devices in non-metropolitan areas, the average score was 2.86, 2.81, which is less than 3 points. The level of understanding and interest in healthcare devices was found to be relatively low. On the other hand, there was a statistically significant difference between the metropolitan area and non-metropolitan area in the total awareness of using IoT healthcare devices ($p<.05$). However, it was found that the awareness level was not high enough because the average score was in the 3-point range.

Table 14

Awareness of IoT healthcare devices by region before COVID-19

Sub-factor	Region	N	M	SD	t	p
Understanding of IoT healthcare device utilization	Metropolitan	294	3.68	1.38	6.035	.000
	Non-metropolitan	218	2.86	1.62		
The need for IoT healthcare device utilization	Metropolitan	294	3.85	1.29	4.883	.000
	Non-metropolitan	218	3.25	1.43		
Interest in IoT healthcare device utilization	Metropolitan	294	3.65	1.66	5.620	.000
	Non-metropolitan	218	2.81	1.68		
Whether IoT healthcare device utilization is helpful for daily life	Metropolitan	294	3.79	1.54	4.760	.000
	Non-metropolitan	218	3.12	1.63		
Awareness of IoT healthcare device utilization	Metropolitan	294	3.74	1.10	7.370	.000
	Non-metropolitan	218	3.01	1.12		

4.9 Differences by Region in e-Health Literacy Before COVID-19

The differences by region in e-health literacy before COVID-19 were analyzed as follows. It is presented in the following Table 15. As a result of comparing the difference in awareness of e-health literacy in the metropolitan area and non-metropolitan areas before COVID-19, the average score of the metropolitan area was higher than the average score of the non-metropolitan area. However, there was no statistically significant difference between the two groups($p>.05$). Also, since the average score in both regions was in the low 3-point range, it was confirmed that the level of basic e-health literacy itself was not very high.

Table 15

E-Health literacy by region before COVID-19

Sub-factor	Region	N	M	SD	t	p
Functional e-health literacy	Metropolitan	294	3.39	1.79	.936	.350
	Non-metropolitan	218	3.24	1.69		
Communicative e-health literacy	Metropolitan	294	3.47	1.53	.252	.801
	Non-metropolitan	218	3.43	1.38		
Critical e-health literacy	Metropolitan	294	3.31	1.53	1.204	.229
	Non-metropolitan	218	3.16	1.37		
e-Health literacy	Metropolitan	294	3.39	1.42	.929	.353
	Non-metropolitan	218	3.28	1.27		

4.10 Differences by Region in the Awareness of IoT Healthcare Device Utilization after COVID-19

The differences by region in the awareness of IoT healthcare device utilization after COVID-19 were analyzed as follows. It is presented in the following Table 16. As a result of comparing the difference in awareness of IoT healthcare device utilization in the metropolitan area and non-metropolitan areas before COVID-19, the average score of the metropolitan area was higher than that of the non-metropolitan area, and the average score improved. On the other hand, the average score was four or more only in whether the use of IoT healthcare devices is helpful for daily life. There was a statistically significant difference between the two groups ($p<.05$). There was no statistically significant difference between the two groups in the other sub-factors and the sum of awareness ($p>.05$). In addition, the metropolitan area showed an average score of 4 or higher in terms of necessity and interest in using IoT healthcare devices. The average score in total

recognition was 4.08, which was four or higher, and in non-metropolitan areas, the average score was 3.92, close to the average of 4 points. Therefore, while college students majoring in sports experienced COVID-19, it was confirmed that IoT healthcare devices were used, and positive awareness about their use increased.

Table 16

Awareness of IoT healthcare devices by region after COVID-19

Sub-factor	Region	N	M	SD	t	p
Understanding of IoT healthcare device utilization	Metropolitan	294	3.89	1.49	.327	.744
	Non-metropolitan	218	3.84	1.48		
The need for IoT healthcare device utilization	Metropolitan	294	4.00	1.56	1.005	.315
	Non-metropolitan	218	3.86	1.54		
Interest in IoT healthcare device utilization	Metropolitan	294	4.04	1.33	.714	.475
	Non-metropolitan	218	3.95	1.50		
Whether IoT healthcare device utilization is helpful for daily life	Metropolitan	294	4.38	1.06	3.048	.002
	Non-metropolitan	218	4.04	1.45		
Awareness of IoT healthcare device utilization	Metropolitan	294	4.08	1.05	1.503	.133
	Non-metropolitan	218	3.92	1.24		

4.11 Differences by Region in e-Health Literacy after COVID-19

The differences by region in e-health literacy after COVID-19 were analyzed as follows. It is presented in the following Table 17. As a result of comparing the difference in awareness of e-health literacy in the metropolitan area and non-metropolitan areas after COVID-19, the average score of the metropolitan area was higher than that of the non-metropolitan area. Improvement was made, but no statistically significant difference (p>.05). The level of e-health literacy that college students majoring in sports can critically accept while getting and understanding health information and services necessary for online health-related decision-making has increased during COVID-19.

Table 17

E-Health literacy by region after COVID-19

Sub-factor	Region	N	M	SD	t	p
Functional e-health literacy	Metropolitan	294	4.15	0.74	.883	.377
	Non-metropolitan	218	4.08	0.82		
Communicative e-health literacy	Metropolitan	294	3.92	1.53	1.084	.279
	Non-metropolitan	218	3.76	1.78		
Critical e-health literacy	Metropolitan	294	3.93	1.43	1.771	.077
	Non-metropolitan	218	3.69	1.69		
e-Health literacy	Metropolitan	294	4.00	0.79	1.888	.060
	Non-metropolitan	218	3.84	1.08		

4.12 Discussion

The discussion of this study is as follows. Regarding the awareness of IoT healthcare device utilization and e-health literacy of college students majoring in sports, there were significant differences in the awareness of IoT healthcare device utilization and e-health literacy, and there were also significant differences by grade and region before and after COVID-19.

First, there were significant differences in the awareness of IoT healthcare device utilization and e-health literacy before and after COVID-19. This is the 4P of personalized, predictive, preventive, and participatory, as the treatment-oriented traditional medical services in medical institutions began to focus on health care and disease prevention with the development of information technology (Yarmohammadi et al., 2019). It can be seen as a result of the process of evolving into a leading healthcare service. In other words, as college students majoring in sports experienced COVID-19, the use of healthcare devices for daily life became more frequent and more natural, and it was interpreted that the overall level of awareness improved and the level of e-health literacy also increased. According to the study results, it will be

necessary to devise a strategy to increase e-health literacy and utilization of IoT healthcare devices by college students majoring in sports.

Second, there were significant differences by grade in the awareness of IoT healthcare device utilization and e-health literacy before COVID-19. This is related to understanding the importance of effectively utilizing sports-related healthcare and related devices as students gain access to and know more about sports-related knowledge and information as their grades progress. Also, health communication is possible before college graduation while experiencing various sports activities, finding sports-related health care information online, interacting with others, and using that information independently (Barańska & Kłak, 2022).

The results of this study suggest that it is necessary to improve the level of e-health literacy while using IoT healthcare devices for college students majoring in sports (Abdullah et al., 2016).

Third, there was no significant difference by grade in the awareness of IoT healthcare device use after COVID-19, but a significant grade difference in e-health literacy was found. While people are experiencing COVID-19, wearable devices among IoT healthcare devices are getting more attention during COVID-19. It supports continuous communication between the computer and the users in order to provide an immediate response to the user's request while ensuring safety against electromagnetic waves, etc., because it is applied in a variety of ways (Filabadi et al., 2020; Linh Hoang Thuy Nguyen et al., 2021).

In particular, since COVID-19 occurred, the convergence of IoT healthcare and wearable devices has been more widely used for health and treatment purposes as well as physical fitness through sports targeting individuals, so there is a significant difference between the grades of college students majoring in sports. Improving the awareness level of IoT healthcare device utilization encourages college students to establish practical strategies in related fields by prioritizing the diversity of health and exercise-related functions of people using IoT healthcare devices after graduating from college. Moreover, it is possible to increase the utilization level of IoT healthcare devices by adding entertainment elements so that users can feel pleasure and interest (Araújo, Mesquita, & Hastie, 2014).

Fourth, after COVID-19, it is not a medium that only needs to view given information unilaterally. However, it is possible to use the instantaneous and interactive advantages found anytime through the Internet or YouTube when people need the information they want. So, increasing the level of e-health literacy while searching for relevant information can affect even health-related attitudes, beliefs, and behaviours of college students majoring in sports (Jeyakumar et al., 2022)

In particular, the result showing that 4th graders had the highest level of critical e-health literacy was the relationship between physical activity, such as regular exercise and body posture, and health while continuously checking and managing personal health data while experiencing COVID-19. The cognitive ability to make critical judgments and decisions about overall health to understand and plan helpful sports activities has improved. In addition, the fact that the total level of e-health literacy was close to 4 points means that college students majoring in sports after COVID-19 used computers and smartphones to learn online scientific principles of physical fitness sports content, which can be said that they had the experience of having a health trainer in my hand while understanding how to manage it. These academic and practical experiences will help college students majoring in sports to demonstrate their professionalism while applying their sports-related knowledge in practice after graduation.

Fifth, there was no significant difference in the awareness of IoT healthcare device utilization by college location by region as the COVID-19 period passed. However, the awareness of IoT healthcare device utilization and the level of e-health literacy were relatively higher than those of COVID-19. College students majoring in sports who are aware of the use of IoT healthcare devices after graduating from college can work with expertise to manage and promote health through sports when the media accessing health information is diversified and rapidly changing and a high level of e-health literacy. Therefore, while paying attention to various knowledge and information related to sports, it is necessary to raise awareness of the use of IoT healthcare devices and to go beyond emphasizing only the improvement of the functional dimension in traditional health literacy. In other words, sports-related communicative and critical e-health literacy that can derive the meaning of health-related information through various forms of mutual communication and utilize and apply health-related information through exercise or sports should be improved.

5.0 Conclusion and Recommendations

This study verified the difference in awareness of IoT healthcare devices and e-health literacy among college students majoring in sports before and after COVID-19. In the results of this study, significant differences were found

between the two variables: the awareness of using IoT healthcare devices and e-health literacy before and after COVID-19, and significant differences were also found between the background variables of college students majoring in sports. Based on this study, results can provide the essential data to enable college students majoring in sports to become talented people in the sports related IoT healthcare field. When an epidemic similar to the time of COVID-19 occurs, college students majoring in sports can effectively use sports-related IoT healthcare devices and improve e-health literacy to help people's health and their everyday lives in the future. College students majoring in sports must know IoT healthcare devices and e-health literacy. Suppose the awareness of IoT healthcare devices utilization and e-health literacy is improved. In that case, it will be a significant opportunity not only for individuals but also for improving the overall health of our society through sports. Therefore, it is necessary to find ways to recognize the effective use of IoT healthcare devices in various aspects and develop e-health literacy levels.

6.0 Implications of the Study

The study highlights the importance of increasing awareness and improving e-health literacy among college students majoring in sports in Korea, particularly IoT healthcare device utilization. This suggests that educational institutions should consider integrating e-health literacy and healthcare devices into their curricula to better prepare students for the evolving healthcare landscape. The findings suggest that there are grade-related differences in awareness and e-health literacy. Universities must recognize these variations and provide targeted resources and education to different grade levels. Exposure to e-health literacy and healthcare devices may lead to better outcomes. The COVID-19 pandemic significantly impacted the perception and utilization of IoT healthcare devices. This underscores the need for institutions and healthcare providers to adapt to changing circumstances and promote using such devices for preventative and remote healthcare. The study highlights the growing importance of wearable IoT healthcare devices during the pandemic. Institutions should explore ways to incorporate these devices into health and fitness programs, and manufacturers should consider adding entertainment elements to enhance user engagement. The study suggests that improving e-health literacy can positively influence health-related attitudes and behaviours among college students majoring in sports. Health promotion campaigns and educational programs should emphasize the role of e-health literacy in fostering healthier lifestyles.

7.0 Limitations and Future Studies

The study's sample size and focus on college students majoring in sports studying in the metropolitan and non-metropolitan areas in Korea limit the size of the populations; however, in the future, studies could benefit from the large sample size, and data can be collected from the more diverse population. This study explored differences before and after COVID-19, but it needs to provide a long-term perspective. Future research could investigate the sustained impact of the pandemic on healthcare device utilization and e-health literacy. Future studies can add more variables to the utilization of e-health devices while conducting sports activities, and more behaviours and attitudes of the sports person can be studied for the long-term effects. More age group people can be studied since this study focused on the awareness and e-health literacy of college students majoring in sports. In summary, this study has important implications for education and healthcare in the context of IoT healthcare devices and e-health literacy among college students majoring in sports. While the findings are valuable, addressing the identified limitations and pursuing future research avenues will help refine our understanding of this evolving field and its broader societal impact.

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