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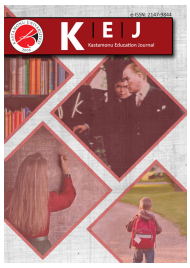

|Araştırma Makalesi / Research Article|

Trend Analysis of Augmented Reality Studies in Sports Science

Spor Bilimlerinde Artırılmış Gerçeklik Çalışmalarının Trend Analizi

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1. Exercise
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Abstract

Purpose: This study aimed to examine the studies related to augmented reality applications in sports science and discuss the results.

Design/Methodology/Approach: Articles selected for analysis were found through searching journals in the Web of Science database from 1975 to 2018 and were examined and searched using the keywords ("physical education" or "physical activity" or "sport$") and ("augmented reality").

Findings: As a result of the search, 44 articles were reached, and 11 articles were excluded from the research because they were unrelated to augmented reality applications or sports science. The publication classification form consists of "Years, Authors Number, Country, Journals, Age, Sample Size, Variables, Sample Method, Research Method, Data Collection Method and Data Analysis Method."

Highlights: A limited number of studies where sports and augmented reality technology are used and interact together. With the spread of augmented reality and similar technologies in the sports sciences, it is thought that such fields as health and education will be positively affected.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, spor bilimlerinde artırılmış gerçeklik uygulamaları ile ilgili çalışmaları incelemek ve buna dayalı sonuçları tartışmaktır.

Materyal ve Yöntem: Web of Science Veritabanı kapsamındaki 1975-2018 yıllarına ait dergiler ("beden eğitimi" veya "fiziksel aktivite" veya "spor$") ve ("artırılmış gerçeklik") anahtar kelimeleri kullanılarak tarandı.

Bulgular: Tarama sonrasında 44 makaleye ulaşıldı. Artırılmış gerçeklik uygulamaları veya spor bilimleri ile ilgili olmadıkları tespit edilen 11 makale araştırma dışı bırakıldı. Yayın sınıflandırma formu "Yıl, Yazar Sayısı, Ülke, Dergi, Yaş, Örneklem, Değişkenler, Örnekleme Yöntemi, Araştırma Yöntemi, Veri Toplama Yöntemi ve Veri Analiz Yöntemi." başlıklarını içermektedir.

Önemli Vurgular: Spor bilimleri ile artırılmış gerçeklik teknolojisinin birlikte kullanıldığı ve etkileşimli olduğu çalışma sayısı sınırlıdır. Spor bilimleri alanında artırılmış gerçeklik ve benzeri teknolojilerin kullanımının yaygınlaşmasıyla birlikte, sağlık ve eğitim gibi alanların olumlu yönde etkileneceği düşünülmektedir.

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INTRODUCTION

Physical activity has been regarded as a component of a healthy lifestyle for a long time (Caspersen, Powell, & Christenson, 1985; Pate et al., 1995; World Health Organization [WHO], 2010). Physical activity involves memory (Chaddock-Heyman, Hillman, Cohen, & Kramer, 2014), selective attention, and concentration (Cadenas-Sanchez et al., 2017; Vanhelst et al., 2016), arithmetic skills (Moore, Drollette, Scudder, Bharij, & Hillman, 2014), linguistic reasoning abilities (Scudder et al., 2014), the level of well-being (Ruiz-Ariza, Torre-Cruz, Redecillas-Peiró, & Martínez-López, 2015), the skill of self-control ability (Donnelly & Lambourne, 2011), socialization (Kato et al., 2017; Tateno, Skokauskas, Kato, Teo, & Guerrero, 2016), and health-related quality of life parameters (Azevedo, Watson, Haighton, & Adams, 2014).

Physical activities affect health positively, so activities and planning for increasing the level of physical activity of individuals will contribute to improving public health (Althoff, White, & Horvitz, 2016; Haskell et al., 2007; Sparling, Owen, Lambert, & Haskell, 2000; WHO, 2010). Unfortunately, although many studies aim to increase physical activity, there is no globally effective method yet (Hallal et al., 2012; Marcus, Nigg, Riebe, & Forsyth, 2000; Sallis, Bauman & Pratt, 1998; WHO, 2010).

Physical inactivity is second on the list of preventable causes of death worldwide after smoking (WHO, 2010). Regular physical activities can prevent or reduce the effects of obesity, hypertension, and cardiovascular disease and provide opportunities for recreational activities (Huang & Reynoso, 2018). Obese children may experience health problems such as hypertension, diabetes, asthma, sleep disorders, liver disease, and psychological problems such as low self-esteem (WHO, 2014). Adding physical education to school curricula for all children and ensuring that children are active through sports by providing them access to adequate and safe facilities are recommendations for combating obesity in children and adolescents (WHO, 2018). Various technologies that use sensing and visualization encourage children and young adults to engage in physical activity (Tong, Gromala, Shaw, & Choo, 2016).

Interest in using information technologies for health services is increasing daily (Garza, 2016). The number of health and lifestyle management systems using wearable technologies and mobile applications is increasing (Yumak & Pu, 2013). Most technologies encourage behavioural changes to be healthy by combining gaming or competition principles (Marquet, Alberico, & Hipp, 2018). It would be appropriate to direct individuals with health problems based on exercise deficiencies to games that they can play with pleasure and, at the same time, increase their physical activity levels (Kim, Lee, Cho, Kim, & Hwang, 2018).

As an augmented reality application, wearable technologies provide extra information or sense to users. Wearable technology can collect data via sensors from the user environment and give a sense of absent material or information via reflectors (Erbas & Demirer, 2014). Augmented reality applications combine physical and virtual worlds into a single interface, allowing users to explore their physical environment, replacing still games with active games (Serino, Cordrey, Mclaughlin, & Milanaik, 2016). In other words, augmented reality creates an environment with virtual and natural materials for users to experience virtual materials without a permanent effect on the real environment (Erbas & Demirer, 2014). In conclusion, it can be said that augmented reality applications, which support the strategy of promoting physical activity among young people, enable participants to be physically active or exercise to play the game via virtual materials or information (Anderson, Steele, Oneill, & Harden, 2017; Clark & Clark, 2016).

Combining augmented reality technology with educational content creates a new type of automated application that enhances the effectiveness and attractiveness of teaching and learning for students in real-life scenarios (Kesim & Ozarslan, 2012). This new combination of educational technology has been used in educational environments for more than twenty years (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014; Chen, Liu, Cheng, & Huang, 2017). Furthermore, trend analysis studies on augmented reality applications show that researchers have used augmented reality in different education branches, including physical and sports education (Arici, Yildirim, Caliklar and Yilmaz, 2019; Bacca et al., 2014). İmamoğlu and İmamoğlu (2018) examined three-dimensional human modelling software in their research; the processes of human modelling, exposure, movement and their output are explained, and it is suggested that these will contribute to the fields of augmented reality, biomechanical studies, motion analysis, sports anatomy and physiology. A sample educational software (mobile application), including a skeletal-muscular system and warm-up exercises, has been developed with augmented reality technology, thus providing a detailed analysis opportunity with a three-dimensional representation of movements or objects without a time limit (İmamoğlu, 2020). Therefore, this mobile application can be an example of the use of augmented reality technology in sports education.

The importance of augmented reality applications in sports science is becoming clearer daily. Therefore, this study examines the studies related to augmented reality applications in sports science and discusses the results. The research questions of the study are listed below:

1. What is the distribution of the studies on augmented reality applications in sports science by years?
2. What is the distribution of studies on augmented reality applications in sports science according to the number of authors?
3. What is the distribution of studies on augmented reality applications in sports science by country?

4. What is the distribution of the studies about augmented reality applications in sports science according to the journals?
5. What is the distribution of the samples in the studies about the augmented reality applications in sports science according to the average age?
6. What is the distribution of the samples in the studies about augmented reality applications in sports science according to their size?
7. Which variables were used in studies related to augmented reality applications in sports science?
8. What sampling methods have been used in studies on augmented reality applications in sports science?
9. What are the research methods used in studies about augmented reality applications in sports science?
10. What data collection methods have been used in studies on augmented reality applications in sports science?
11. What are the data analysis methods used in studies about augmented reality applications in sports science?

METHOD

The content analysis method provides a systematic examination of the content of documents in order to classify and interpret the essential elements (Tavsancıl & Aslan, 2001). The content analysis method obtained detailed information about the selected topics and trends. In order to explain the data collected within the scope of the research, content analysis was applied from qualitative data analysis methods.

Within the scope of the research, journals in the Web of Science database from 1975 to 2018 were examined and searched using the keywords "physical education" or "physical activity", or "sport", and "augmented reality." As a result of the search, 44 articles were reached, and 11 articles were excluded from the research because they were unrelated to augmented reality applications or sports science. Seven articles in which augmented reality expression is used only in the text and focus on virtual reality, motion capture, algorithm analysis, and image-processing techniques are excluded. In addition, four articles contain augmented reality technology but are not directly related to sports and science. These articles compare the effects of two different augmented reality methods, examining the effects of augmented reality in environmental planning, application examples of augmented reality in archaeology, and using augmented reality in object scanning and modelling. These four articles are excluded from the review as they are unrelated to sports science. After removing articles unrelated to the research topic, 33 were included in the publication classification form developed by the researchers based on the "The Educational Technology Publication Classification Form" (Goktas et al., 2012). The publication classification form consists of "Years, Authors Number, Country, Journals, Age, Sample Size, Variables, Sample Method, Research Method, Data Collection Method and Data Analysis Method.". Thirty-three articles, which have been reviewed, have been listed in the attached table at the end of the article (Appendix 1).

FINDINGS

In this section, information about the year of publication of the studies related to augmented reality applications in sports science, distribution according to journals, distribution according to author numbers, distribution according to countries, research methods used, sample sizes, sampling methods, age averages of samples, data collection methods used, data analysis methods used.

The distribution of studies on augmented reality applications in sports science by years, and number of authors have been examined and given in Table 1.

Table 1. Distribution of studies by years, number of authors

Years	f	%	Number of authors	f	%
2018	10	30,3	One Author	5	15,15
2017	12	36,36	Two Authors	1	3,03
2016	2	6,06	Three Authors	8	24,24
2015	4	12,12	Four Authors	6	18,18
2014	1	3,03	Five Authors	5	15,15
2013	1	3,03	Six Authors	4	12,12
2012	2	6,06	Seven Authors	3	9,09
2009	1	3,03	Nine Authors	1	3,03
Total	33	100	Total	33	100

When the distribution of studies by year is examined, it is understood that the studies conducted in 2017 (f=12) and 2018 (f=10) are more than the studies conducted in previous years. The first study with research criteria was published in 2009 (f=1). A total of 11 studies have been published by 2017 and this number is insufficient. In 2017 and 2018, there was a remarkable increase in the number of publications.

When the studies were examined according to the number of authors, it was found that the number of authors varied between one and nine, but there were no eight authors. It is understood that the articles with three authors (f=8) were more than the other

articles. There is only one article with nine authors. Apart from these, the distribution of the number of articles is similar according to the number of authors.

The distribution of studies on augmented reality applications in countries and journals given in Table 2.

Table 2. Distribution of studies by countries and journals

Countries	f	%	Journals	f	%
USA	35	26,32	Games for Health Journal	3	9,09
Spain	14	10,53	Computers & Education	2	6,06
Germany	13	9,77	Computers in Human Behavior	2	6,06
Taiwan	12	9,02	JMIR Serious Games	2	6,06
Republic of Korea	11	8,27	Archives of Budo	1	3,03
Pakistan	6	4,51	Apunts Educación Física Y Deportes	1	3,03
Poland	6	4,51	Biomedical Engineering: Applications, Basis, and Communications	1	3,03
Tunisia	6	4,51	Cardiology in The Young	1	3,03
China	5	3,76	Etri Journal	1	3,03
Korea	5	3,76	IEEE/ACM Transactions on Audio, Speech and Language Processing (TASLP)	1	3,03
Brazil	4	3,01	International Journal of Advanced Computer Science and Applications	1	3,03
United Kingdom	4	3,01	International Journal of Health Geographic	1	3,03
Australia	3	2,26	International Journal of Sports Marketing and Sponsorship	1	3,03
Japan	3	2,26	JMIR Mhealth and Uhealth	1	3,03
Netherlands	2	1,50	Journal of Advanced Mechanical Design, Systems, and Manufacturing	1	3,03
Singapore	2	1,50	Journal of The American Heart Association	1	3,03
Austria	1	0,75	Journal of Human Sport and Exercise	1	3,03
Israel	1	0,75	Journal of Medical Internet Research	1	3,03
Total	133	100	Journal of Physical Therapy Science	1	3,03
			KSII Transactions on Internet & Information Systems	1	3,03
			Microsystem Technologies	1	3,03
			Mobile Networks and Applications	1	3,03
			Multimedia Tools and Applications	1	3,03
			Pattern Analysis and Applications	1	3,03
			Pediatric Exercise Science	1	3,03
			Public Health Research & Practice	1	3,03
			Science Advances	1	3,03
			Sustainability	1	3,03
			Total	33	100

When the distribution of the authors country is examined, it has been seen that the USA (f=35) is in the first place with a rate of 26.32%. The distribution percentages of authors by country are Spain (f=14) 10.53%, Germany (f=13) 9.77%, Taiwan (f=12) 9.02% and Republic of Korea (f=11) 8.27%. The distribution of studies, according to journals, shows a homogeneous structure.

The distribution of the samples according to the average age, sample size and variables are given in Table 3.

Table 3. Distribution of samples according to the average age, sample size and variables

Ages (years)	f	%	Sample size (person)	f	%	Variables	f	%
11-15	1	3,03	0-100	5	15,15	Physical Activity	13	24,07
16-20	3	9,09	101-200	5	15,15	Behaviors	7	12,96
21-25	3	9,09	201-300	3	9,09	Learning Outcomes	5	9,26
26-30	2	6,06	301-400	1	3,03	Usability	3	5,55
31-35	1	3,03	401-500	1	3,03	Demographic Variables	2	3,70
36+	1	3,03	501+	4	12,12	Enjoyment	2	3,70
Unspecified	22	66,67	Unspecified	14	42,42	Motivation	2	3,70
Total	33	100	Total	33	100	Others	20	37,03
						Total	54	100

When the average age of the samples in the studies is examined, it is seen that the trend is in the 16-20 (f=3) and 21-25 (f=3) age groups. The average age was not reported in 66.67% of the studies. The sample sizes in the study were divided into 100-unit categories and evaluated. When the sample sizes in the studies are examined, the first place with 15.15% is the researches in

which 0-100 (f=5) and 101-200 (f=5) individuals participate. The researchers with 501 and more individuals are in third place with 12.12%. Fifty-four variables, which have been grouped in nine categories, have been examined in studies. The most studied variables have been grouped under the Physical Activity (f=13) category, which covers variables related to physical activity. The next biggest studies category covers behavioral variables as named behavior (f=7). The next group usability (f=3) follows by demographic variables (f=2), enjoyment (f=2) and motivation (f=2). The biggest number of variables has been grouped as others (f=20), covering variables used just once in studies.

Sampling methods, and research methods are given in Table 4.

Table 4. Sampling methods, and research methods

Sampling methods	f	%	Research methods	f	%
Purposeful	10	30,30	Development	12	36,36
Easy Accessible	7	21,21	Predictive	9	27,27
Convenient	1	3,03	Weak Experimental	5	15,15
Voluntary	1	3,03	Correlational	3	9,09
Unspecified	14	42,42	Descriptive	2	6,06
Total	33	100	Literature Review	2	6,06
			Total	33	100

Four different sampling methods were used in the studies. When the sampling methods used in the studies are examined, purposeful (f=10) takes first place with 30.30%. Voluntary (f=1) and Convenient (f=1) sampling methods were used in only one study with 3.03%. In 42.42% of the studies, the sampling methods was not specified.

When Table 4 is examined, it is seen that six different research methods are used in the studies. When the research methods used in the studies are examined, the development method (f=12) is ranked first with 36.36%, and the predictive method (f=9) is ranked second with 27.27%. On the other hand, descriptive methods (f=2) and literature review (f=2) 6.06% of the studies have been the least preferred methods.

Data collection methods, and data analysis methods are given in Table 5.

Table 5. Data collection methods, and data analysis methods

Data collection methods	f	%	Data analysis methods	f	%
Questionnaire	10	33,33	Descriptive Analysis	13	21,31
Survey	4	13,33	Chi-Square	10	16,39
Observation	2	6,67	Anova	6	9,84
Physical Activity Monitor	2	6,67	T-Test	5	8,20
App Logs	1	3,33	Ancova	3	4,92
Electronic Medical Record	1	3,33	Correlations	3	4,92
Logs	1	3,33	Regression	3	4,92
Mobile Phone Data	1	3,33	Wilcoxon	3	4,92
Muscle Performance	1	3,33	Mann–Whitney U Tests	2	3,28
Iphone Health App	1	3,33	Structural Equation Modeling	2	3,28
Pokemon Go App Logs	1	3,33	Bonferroni	1	1,64
Postings	1	3,33	Fisher's Exact Test	1	1,64
System Logs	1	3,33	Linear Regression Model	1	1,64
Test	1	3,33	Manova	1	1,64
2x Survey	1	3,33	Multilevel Modeling Analysis	1	1,64
4X Test	1	3,33	Multiple Regression	1	1,64
Total	30	100	Robustness Test	1	1,64
			Sensitivity Analysis	1	1,64
			Spearman's Correlation	1	1,64
			Tukey	1	1,64
			Z-Test	1	1,64
			Total	61	100

Sixteen different data collection methods were used in the studies. However, when the data collection methods used in the studies are examined, it is seen that the questionnaire (f=10, 33.33%) is used the most. Therefore, it is thought that using the Questionnaire method more than other methods provides ease of data collection.

Twenty-one different analysis methods were used in the studies. Descriptive analysis (f=13, 21.31%) and Chi-square (f=10, 16.39%) take the first place.

RESULTS AND DISCUSSION

This study examines the studies on augmented reality applications in sports science and shows that the trend toward this subject has increased in recent years. Furthermore, the increase in the use of augmented reality in sports science generally coincides with the increase in the use of augmented reality applications in education.

Different field surveys show that the trend toward the use of augmented reality in education, which began at the end of the 2000s, has continued to increase for more than a decade as in augmented reality studies in sports education (Akçayır & Akçayır, 2017; Altinpulluk, 2019; Özdemir, 2017). According to the results of this study, although augmented reality applications in sports science have been studied for many years, it is clear that there has been a tendency to work more on these issues in recent years.

When the augmented reality studies in sports science were evaluated according to the number of authors, it was found that the studies with three authors (f=8) were the most. Three authors were followed by four authors (f=6), one and five authors (f=5), six authors (f=4), seven authors (f=3), and two and nine authors (f=1).

According to the content analysis process, 133 authors in the 33 studies examined, 26.32 per cent of the studies were carried out in the USA, and this was the most significant number of authors. Spain follows the USA with 10.53 per cent, Germany with 9.77 per cent, Taiwan with 9.02 per cent and South Korea with 8.27 per cent. The authors of the studies are from 18 different countries. The trend analysis results of augmented reality use in education in the decade between 2006 and 2016, the most studies were published by the authors in institutions in Taiwan (f=23) in the ten years. Taiwan is followed by the USA (f=8), Spain (f=3) and South Korea (f=3) (Altinpulluk, 2019). One study examined 55 studies published in SSCI index journals between 2011 and 2016; the most publications were published by Taiwanese (f=22) authors, followed by Spanish (f=12) and USA (f=9) authors (Chen et al., 2017).

According to the journals, the distribution of the studies examined in this study shows a homogeneous structure. Among the reasons why the distribution is in this way, no journal accepts only studies in the field of augmented reality. Instead, journals generally accept technology, education, and sports studies. As a result, 28 different journals have published studies.

When the participants in the study were examined according to their ages, it was observed that the participants in the 16-20 and 21-25 age groups (f=3) were the largest group, followed by the 26-30 (f=2) age groups and followed by 11-15, 31-35 and 36+ age groups in three studies. Among the reasons why these age groups are mainly involved in the studies is the use of technology in augmented reality. The applications of augmented reality technology in health will be practical, especially in older individuals. The age range of technology use is increasing daily, so it would be beneficial to conduct studies involving augmented reality applications for older individuals.

After the examination, it was seen that the largest group was the sample size in the range of 0-100 and 101-200 (f=5) participants. These groups are followed by the sample sizes of 501+ (f=4), 201-300 (f=3), 301-400 and 401-500 (f=1). Considering the prevalence of technology use, it can be argued that sample sizes are not sufficient. The sample size is not specified in 42.42% of the studies. The reasons for not specifying the sample size may show the difference between the methods used in the studies. When we compare the results according to the sample size, it is seen that the sample sizes of the studies examining the use of augmented reality in education are dealt with at different ranges. As a result of 25 experimental studies published in SSCI index journals between 2011 and 2016 and identified ten studies in the 30-59 sample size, seven with greater than 100 samples, six studies in the 66-99 sample size, and two studies in the 0-29 sample size (Özdemir, 2017). In the studies, the most frequently used sample size generally was found to be 30-200 (Bacca et al., 2014; Chen et al., 2017). In addition, sample size information was not included in 14 of 33 studies.

It has been seen that fifty-four variables were examined in 33 journal articles about using augmented reality in sports science. Variables have been listed: physical activity, behaviours, learning outcomes, usability, demographic variables, enjoyment, motivation and others. The third-largest variable group, learning outcomes, is organized according to learning outcomes, including verbal knowledge, intellectual skills, cognitive strategies, attitudes and motor skills (Gagné & Driscoll, 1988). Learning outcomes are the most studied variables in empirical studies with augmented reality (Özdemir, 2017). Also, other educational researchers found that learning outcomes are the most mentioned variables as part of the advantages of augmented reality in education (Akçayır & Akçayır, 2017; Altinpulluk, 2019; Bacca et al., 2014). Besides learning outcomes, usability, demographic variables, enjoyment and motivation are other standard variables between sports science and education in augmented reality studies.

When the studies using augmented reality in sports science are examined, it is seen that the most commonly used sampling method is purposeful (f=10) sampling. This sampling method is followed by the easily accessible (f=7), and it is also seen that voluntary and Convenient sampling methods are used in one study.

When the research methods used in the studies are examined, it is seen that the development (f=12) method is the most used research method. After the studies using the predictive (f=9) method, weak exp (f=5) and correlation (f=3) method, which is one of the most preferred research methods, were used. In addition, descriptive (f=2) and review (f=2) studies were determined in the literature. Finally, it is seen that the mixed method is the most commonly used research method in studies examining the use of augmented reality in education and in studies dealing with different time intervals (Altinpulluk, 2019; Bacca et al., 2014; Chen et

al., 2017). It is thought that the predominantly use of the development method is since augmented reality technology is a new technology and is in the process of development. The lack of literature review can also be explained by the fact that augmented reality is a new area and does not contain enough resources to investigate.

When the data collection tools in the studies are examined, it is seen that the questionnaire (f=10) is the most preferred method. In addition, survey (f=4), observation (f=2) and physical activity monitoring (f=2) are other standard data collection tools. When these results and the studies of augmented reality use in education are examined, the questionnaire is the most commonly used data collection tool (Altinpulluk, 2019; Bacca et al., 2014). However, in a study conducted between 2011 and 2016, tests were the most commonly used data collection tool (Chen et al., 2017).

When the augmented reality studies are examined in sports science; it is seen that the most commonly used data analysis method is Descriptive analysis (f=13). Descriptive analysis was followed by Chi-square (f=10), Anova (f=6), t-test (f=5), correlations, Wilcoxon, Ancova and Regression (f=3).

The topics, contents, and results of the articles reviewed are given below:

It is seen that nine articles have developed software/hardware products. The three studies identified one of the wearable technologies derived from augmented reality; It is recommended that feedback and other interactions from the digital glove, magnetic sensitive electronic skin and headphones will be helpful in the augmented reality and Sports area. In the other six articles, augmented reality technology is used directly in refined products. These products provide users with the help of objects defined by image processing. It can provide users with a wide range of content, such as advertising, distance measurements, digital objects drawn on physical media, athletes, and competitions. Some of the studies on the use of augmented reality in education between 2011 and 2016 did not use research methods. These studies revealed that system design was developed to use augmented reality in education (Chen et al., 2017).

Pokemon Go game; is based on the collection, development, and inter-competitive fighting of pokemon displayed around the real world with the help of augmented reality technology. Of the 33 articles examined, 17 were related to the Pokemon Go game. It is stated that Pokemon Go increases physical activity, positively affects social relationships, and promotes the discovery of the environment. In some cases, the need to have a high level of self-determination to play sports is not necessary for Pokemon Go. In these cases, it increases activity level, reducing the risk of developing cardiovascular diseases. In addition, individuals had higher levels of physical activity, were more socialized, and had a better mood on the days of playing Pokemon Go (Marquet, Alberico, Adlakha, & Hipp, 2017).

Six articles have an impact on individuals regardless of Pokemon GO. In these studies, augmented reality applications improve spatial orientation and estimation capacity, positively affect academic achievement and education by helping the instructor and learning, improve athletes' strength and technique, and increase patient cooperation.

In one of the articles, the relationship between real sports and their adaptations digitized using technologies such as augmented reality was analyzed using concrete examples. This article demonstrates the interdependence between sports and technology and states that digitalization directly affects communication about sports and sports.

CONCLUSION

In this research, the studies about augmented reality applications in sports science with the help of various variables are examined, and the current situation is revealed. A limited number of studies show that sports and augmented reality technology are used and interact together. Therefore, it will be beneficial to increase studies related to technology use in the sports sciences field. With the spread of augmented reality and similar technologies in the sports sciences, it is thought that such fields as health and education will be positively affected.

Declaration of Conflicting Interests

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

As this research is a Trend Analysis study, an "ethics committee report" was not presented.

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Appendix 1. List of Reviewed Journal Articles (In Alphabetical Order)

N	Selected Articles
1.	Barbero, E. M., Carpenter, D. M., Maier, J., & Tseng, D. S. (2018). Healthcare encounters for Pokémon Go: Risks and benefits of playing. Games for health journal, 7(3), 157-163.
2.	Barkley, J. E., Lepp, A., & Glickman, E. L. (2017). "Pokémon Go!" may promote walking, discourage sedentary behavior in college students. Games for health journal, 6(3), 165-170.
3.	Beach, C., Billstrom, G., Anderson Steeves, E. T., Flynn, J. I., & Steeves, J. A. (2019). The physical activity patterns of greenway users playing Pokémon Go: A natural experiment. Games for health journal, 8(1), 7-14.
4.	Bermúdez, G. S. C., Karnaushenko, D. D., Karnaushenko, D., Lebanov, A., Bischoff, L., Kaltenbrunner, M., ... & Makarov, D. (2018). Magnetosensitive e-skins with directional perception for augmented reality. Science Advances, 4(1), eaao2623.
5.	Cheikhrouhu, E., Jabri, I., Lakhoua, M. N., Mlouhi, Y., Battikh, T., & Maalej, L. (2015). Application of Image Processing Techniques for TV Broadcasting of Sporting Events. International Journal of Advanced Computer Science and Applications, 6(6), 138-148.
6.	Delabrida, S., D'Angelo, T., Oliveira, R. A. R., & Loureiro, A. A. F. (2016). Wearable hud for ecological field research applications. Mobile Networks and Applications, 21(4), 677-687.
7.	Escaravajal-Rodríguez, J. C. (2018). Pokémon GO and its Influence on Spanish Facebook Users. Apunts: Educació Física i Esports, (133).
8.	Freeman, B., Chau, J., & Mihrshahi, S. (2017). Why the public health sector couldn't create Pokémon Go. Public Health Res Pract, 27(3).
9.	Gómez-García, M., Trujillo-Torres, J. M., Aznar-Díaz, I., & Cáceres-Reche, M. P. (2018). Augment reality and virtual reality for the improvement of spatial competences in Physical Education. Journal of Human Sport and Exercise, 13(2proc), S189-S198.
10.	Hebbel-Seeger, A. (2012). The relationship between real sports and digital adaptation in e-sport gaming. International Journal of Sports Marketing and Sponsorship, 13 (2), 43-54.
11.	Hsiao, K. F. (2013). Using augmented reality for students health-case of combining educational learning with standard fitness. Multimedia tools and applications, 64(2), 407-421.
12.	Kao, C. H., Chen, C. C., Jhu, W. Y., Tsai, Y. T., Chen, S. H., Hsu, C. M., & Chen, C. Y. (2018). Novel digital glove design for virtual reality applications. Microsystem Technologies, 24(10), 4247-4266.
13.	Kim, H., Lee, H. J., Cho, H., Kim, E., & Hwang, J. (2018). Replacing self-efficacy in physical activity: Unconscious intervention of the AR game, Pokémon GO. Sustainability, 10(6), 1971.
14.	Kim, S., Choi, B., Jeong, Y., Hong, J., & Kim, K. (2014). Novel hybrid content synchronization scheme for augmented broadcasting services. ETRI Journal, 36(5).
15.	Koh, H. E., Oh, J., & Mackert, M. (2017). Predictors of playing augmented reality mobile games while walking based on the theory of planned behavior: web-based survey. JMIR mHealth and uHealth, 5(12), e8470.
16.	Krittanawong, C., Aydar, M., & Kitai, T. (2017). Pokémon Go: digital health interventions to reduce cardiovascular risk. Cardiology in the Young, 27(8).
17.	Lee, R. G., Tien, S. C., Chen, C. C., & Chen, Y. Y. (2012). Development of An Augmented Reality-Oriented Game System for Stroke Rehabilitation Assessment. Biomedical Engineering: Applications, Basis and Communications, 24(05), 435-445.
18.	Ma, B. D., Ng, S. L., Schwanen, T., Zacharias, J., Zhou, M., Kawachi, I., & Sun, G. (2018). Pokémon GO and physical activity in Asia: multilevel study. Journal of medical Internet research, 20(6), e9670.
19.	Mahmood, Z., Ali, T., Khattak, S., Hasan, L., & Khan, S. U. (2015). Automatic player detection and identification for sports entertainment applications. Pattern Analysis and Applications, 18(4), 971-982.
20.	Mahmood, Z., Ali, T., Muhammad, N., Bibi, N., Shahzad, I., & Azmat, S. (2017). EAR: Enhanced augmented reality system for sports entertainment applications. KSII Transactions on Internet and Information Systems (TIIS), 11(12), 6069-6091.
21.	Marquet, O., Alberico, C., & Hipp, A. J. (2018). Pokémon GO and physical activity among college students. A study using Ecological Momentary Assessment. Computers in Human Behavior, 81, 215-222.
22.	Marquet, O., Alberico, C., Adlakha, D., & Hipp, J. A. (2017). Examining motivations to play Pokémon GO and their influence on perceived outcomes and physical activity. JMIR serious games, 5(4), e8048.
23.	Moon, J., Koo, D., Kim, K., Shin, I., Kim, H., & Kim, J. (2015). Effect of ski simulator training on kinematic and muscle activation of the lower extremities. Journal of Physical Therapy Science, 27(8), 2629-2632.
24.	Muñoz-Cristóbal, J. A., Gallego-Lema, V., Arribas-Cubero, H. F., Martínez-Monés, A., & Asensio-Pérez, J. I. (2017). Using virtual learning environments in bricolage mode for orchestrating learning situations across physical and virtual spaces. Computers & Education, 109, 233-252.
25.	Nemet, D. (2017). Childhood obesity, physical activity, and exercise. Pediatric exercise science, 29(1), 60-62.
26.	Osaki, A., Taniguchi, H., & Miwa, Y. (2009). Collaborative aerial-drawing system for supporting co-creative communication. Journal of Advanced Mechanical Design, Systems, and Manufacturing, 3(1), 93-104.
27.	Ranjan, R., & Gan, W. S. (2015). Natural listening over headphones in augmented reality using adaptive filtering techniques. IEEE/ACM Transactions on Audio, Speech, and Language Processing, 23(11), 1988-2002.
28.	Rasche, P., Schlomann, A., & Mertens, A. (2017). Who is still playing Pokémon Go? A web-based survey. JMIR serious games, 5(2), e7197.
29.	Rauschnabel, P. A., Rossmann, A., & tom Dieck, M. C. (2017). An adoption framework for mobile augmented reality games: The case of Pokémon Go. Computers in Human Behavior, 76, 276-286.
30.	Ruiz-Ariza, A., Casuso, R. A., Suarez-Manzano, S., & Martínez-López, E. J. (2018). Effect of augmented reality game Pokémon GO on cognitive performance and emotional intelligence in adolescent young. Computers & Education, 116, 49-63.
31.	Witkowski, K., Sobecki, J., Maslinski, J., Cieslinski, W., Rokita, A., & Kalina, R. M. (2016). The use of augmented-reality technology to improve judo techniques. Premises, assumptions, methodology, research tools, preliminary scenarios-the first stage of the study. Archives of Budo, 12, 355-367.
32.	Wong, F. Y. (2017). Influence of Pokémon Go on physical activity levels of university players: a cross-sectional study. International journal of health geographics, 16(1), 1-12.
33.	Xian, Y., Xu, H., Xu, H., Liang, L., Hernandez, A. F., Wang, T. Y., & Peterson, E. D. (2017). An initial evaluation of the impact of Pokémon GO on physical activity. Journal of the American Heart Association, 6(5), e005341.