Literature review on technologies and games that motivated people to practice physical activity during the pandemic

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Abstract: With the pandemic arrival, changes in people's lives have become increasingly frequent, also affecting the education and physical health sector. As a consequence, many schools, gyms and clubs ended up closing. However, so that the activities did not stop, there was a need to adapt to technology, involving digital classes, physical activities with the use of applications and data analysis using data science. For this article, a systematic review was carried out, with the objective of evaluating the motivation to practice physical activities during the pandemic (2020 - 2021). We found (226) articles, selected (49) articles and extracted (16). The results, for the most part, were positive for the use of technologies in the practice of physical activities. Thus, the research carried out here reinforces the importance for more research in the area of physical education, health and well-being of people, mainly due to the decrease in this practice due to Covid-19.

Keywords: Covid-19 pandemic, physical education, technological games, gamification, scholar sports.

Revisão de literatura sobre tecnologias e jogos que motivaram as pessoas na prática de atividade física durante a pandemia

Resumo: Com a chegada da pandemia, as mudanças na vida das pessoas se tornaram cada vez mais frequentes, afetando também o setor de educação e saúde física. Como consequência, muitas escolas, academias e clubes acabaram fechando. Porém, para que as atividades não parassem, houve a necessidade de adaptação à tecnologia, envolvendo aulas digitais, atividades físicas com o uso de aplicativos e análise de dados usando ciência de dados. Para este artigo, foi realizada uma revisão sistemática, com o objetivo de avaliar a motivação para a prática de atividades físicas durante a pandemia (2020 - 2021). Foram encontrados (226) artigos, selecionados (49) artigos e extraídos (16). Os resultados, em sua maioria, foram positivos para o uso de tecnologias na prática de atividades física. Assim, a pesquisa aqui realizada reforça a importância para mais pesquisas na área de educação física, saúde e bem-estar das pessoas, principalmente devido à diminuição dessa prática devido à Covid-19.

Palavras-chave: Pandemia de Covid-19, educação física, jogos tecnológicos, gamificação, esportes escolares.

1. Introduction

When the pandemic started in 2020, schools around the world were forced to close their doors to classes held in the classroom, thus leaving online classes (Lima e Isotani, 2022). This sudden change from classes held online or in the classroom was very challenging (Bhinder *et al.*, 2021). The defiance of this change was as difficult for teachers as it was for students, both having different types of difficulties. In the area of Physical Education (PE), there was a lot of difficulty in relation to the practice of sports and physical exercises, as the practices were carried out the classrooms, so when the lockdown occurred, they had to go to online classes.

For many students, pandemic left them less willing to study, so many teachers created classes within gamification, so that students did not lose the will to study (Lima

et al., 2021). Physical Education Classes (PEC) have become more difficult to practice due to the fact that students often live in apartments and there is no contact with other children. In addition, outside the school context, for example, for military personnel, adults or even the elderly people, the practice of Physical Activities (PA) was impaired during the pandemic. It is known that the practice of sports is essential to maintain health (Carvalho; Freitas e Akerman, 2021), in addition to a balanced nutrition.

Most people forced to stay at home or adopt isolation protocols to prevent transmission of the virus (Tel, 2021). For this purpose, multiple exercise modes can be applied in home, including aerobic exercise using stationary bikes or rowing ergometers, body-weight training, dance exercise and active gaming (Hammami *et al.*, 2020), but not everyone has this equipment at home. Therefore, some pandemic studies indicated that technology could help in the practice of PA without having it present (Okmawati, 2020).

This paper presents technologies capable of helping people, including teachers and students to practice PA during the pandemic. We adopted a systematic literature review (SLR) methodology, based on the article by (Kitchenham *et al.*, 2009). The article is divided as follows: Section 1, the introduction was presented. Section 2 presents the methodology for conducting the SLR. Section 3 presents the discussion of articles extracted during the SLR. Finally, Section 4 presents final considerations.

2. Methodology

The methodology is represented in the Figure 1 and was divided into 3 main phases: (i) Planning, (ii) Execution and (iii) Summarization. Each step of the
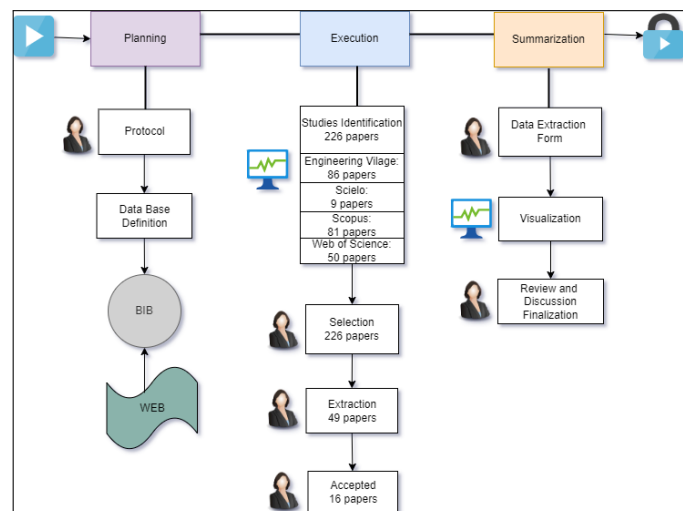

Figure 1. Process for conducting our systematic literature review.

methodology will be presented and explained in one of the following subsections. We used the StArt*Tool to help us in a SLR.

2.1. Planning

The first step is planning which leads to the protocol and arrives at the choice of data definition. The SLR methodology adopted in this work was based on (Kitchenham *et al.*, 2009; Lima e Isotani, 2022), We seek to answer the following research questions:

1. How could gamified apps and technologies help physical education practice during the pandemic?

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2. What are the challenges and advantages of using apps for sports practices during the pandemic?

The string search that was used for this study was: "(COVID OR COVID-19 OR Pandemic OR Quarantine OR Sars-Cov-2 OR Lockdown) AND (Physical education OR Physical; Exercise OR Artistic Exercises OR Body OR Balance OR Dance OR Fitness OR Sports OR Gymnastic OR P. E.) AND (Game OR Game-Based OR Gamefied OR Games OR Serious Games OR Gamification OR Technology)", reaching a total of 226 articles found using the motor search: title, abstract and keywords (TAK). For literature searches, we used the following 4 data sources: (i) Engineering Village, (ii) Scopus, (iii) Web of Science and (iv) Scielo (see Figure 2(a)). The source Engineering Village returned 86 articles (38%), Scopus returned 81 articles (36%), Web of Science returned 50 articles (22%) and finally, Scielo returned 9 articles (4%).

2.2. Selection

In this step we read the TAK of 226 articles, taken from the 4 research sources, presented in Figure 2(a). On the left of Figure 2(b) is shown that 49 (22%) papers were accepted, 2 papers (1%) were duplicated and 175 papers (77%) were rejected. A reading priority was carried out automatically by the StArt Tool, through the frequency of "string words" that appeared in the TAK. Most articles were rejected because they did not pass the inclusion criteria, thus they were automatically excluded. Figure 2(b) on the right we have the order of reading priority.
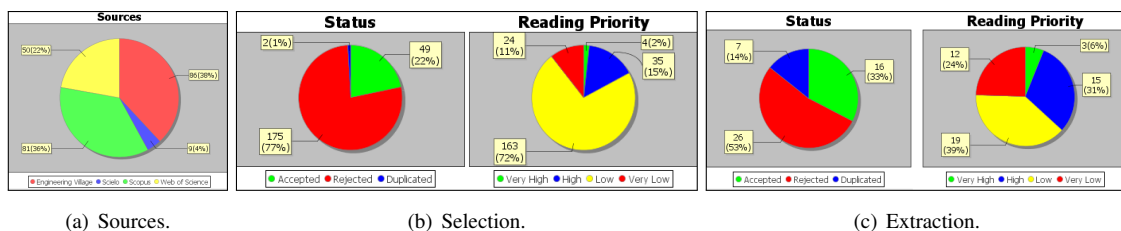

(a) Sources.　　　　　(b) Selection.　　　　　(c) Extraction.

Figure 2. Search source, Selection step (status and reading priority) and Extraction step (status and reading priority).

2.3. Extraction

In this step we read full 49 articles and the process is shown in Figure 2(c), on the left, represents a pie chart indicating that: 26 papers (53%) were rejected, 7 duplicate articles (14%), articles that were very similar of other articles from the same group of authors, and 16 papers (33%) were accepted articles. Reading Priority was organized following the criteria established by StArt Tool, in Figure 2(c) on the right. Figure 3 represents the attributes extracted from each article in order to make
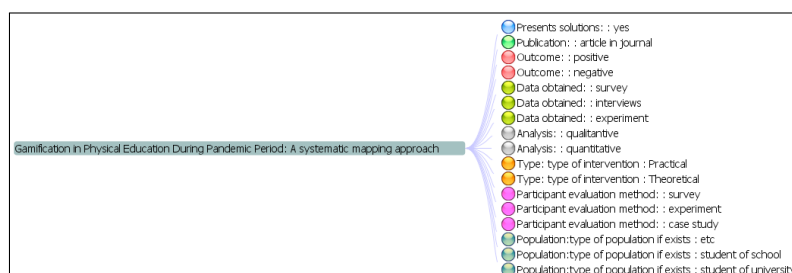

Figure 3. Attributes of characteristics considered in the articles extraction step.

a more adequate summary of the articles to be analyzed and later discussed in this

work: (a) publication = {yes, no}, (b) population type = {school, university, other}, (c) analysis = {quantitative, qualitative, mixed}, (d) data obtained = {survey, interviews, experiment}, (e) participant evaluation method = {survey, experiment, study case}, (f) presented a solution = {yes, no}, (g) type of intervention = {practical, theoretical, other} and (h) main outcomes = {positive, neutral, negative}.

2.4. Summarization

The Summarizing, being the last part of our methodology. In this step we conducted the data visualization. In this sense, of the 16 articles accepted, the studies of papers accepted in this step were carried out in different parts of the world, as shown in Figure 4. Considering some articles were investigated in more than one country
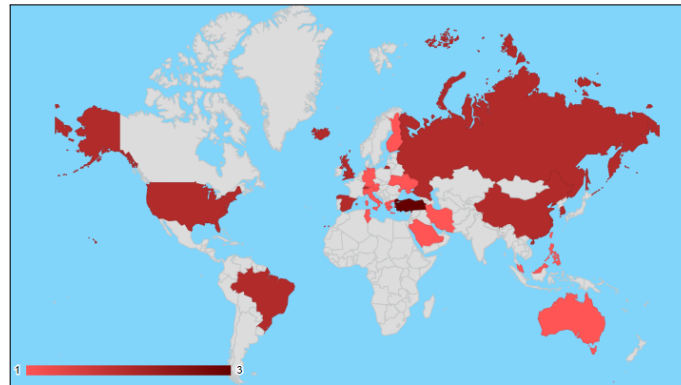

Figure 4. This figure represents the countries in which the selected and accepted articles were published.

simultaneously. The colors represent the number of articles, with 1 article, represented by the salmon color, and the maximum 3 articles, represented by the dark red color. Turkey was the country that the highest number of studies were conducted, with 3 articles published, within which it was chosen and accepted, while Brazil, for example, had 2 studies in articles published during pandemic.

A word cloud is a visually hierarchical list, a way to present the content items of abstracts of accepted papers from the extraction phase. The words that appeared the most in the abstracts of the 16 extracted articles were Covid-19, Physical and Pandemic. The

Figure 5. Cloud of the most frequent words during the extraction stage developed using the StArt tool.

words that appear least are Sport, Physical Activity (PA) and Risk.

Table 1 presents important data from each of the 16 papers and a brief summary of each article. Each column represents data from the articles: (a) article ID, (b) Authors, (c) Publication year, (d) Country where study was conducted, (e) StArt Tool score, (f) Reading priority, (g) Paper approach and (h) Overview. The table rows demonstrate that $81,25\%$ of papers were published in 2021 and $18,75\%$ of papers were published in 2020. Besides that, $81,25\%$ of papers, the authors highlighted a positive approach, while $12,5\%$ of papers are negative and $6,25\%$ are considered neutral approaches during the pandemic.

Table 1. Summarizing of results considering the articles were extracted and results of StArt Tool.

ID	Authors	Year	Country	Score	Priority	Approach	Overview
1	Bhinder *et al.*	2021	Ukraine	95	High	Traditional sports applied to older cadets during the pandemic with for improving performance and emotional stability.	Positive
2	Benzing *et al.*	2021	Austria, Brazil, China, Malaysia, Finland, Spain, Iceland, Germany, Italy, Russia, Philippines, Iran, Greece, Taiwan, Turkey, United Kingdom, United States and Switzerland.	100	Low	Survey conducted in several countries in order to find out about physical inactivity during the pandemic.	Negative
3	Petrusic e Stemberger	2021	Slovenia	57	High	Research on PE teaching models at the distance classes.	Positive
4	Nie *et al.*	2021	China	97	High	Questionnaire on physical and mental health during the pandemic.	Positive
5	Rodrigues; Postolache e Cercas	2021	Switzerland	45	High	A game that studies the exergames' effects as they can affect the physical and cognitive of an individual's performance.	Positive
6	Parker *et al.*	2020	Australia	74	High	Home Activity using platforms during PA in the lockdown.	Positive
7	Kim *et al.*	2021	South Korea	73	Low	Questionnaire about parents' concerns about school closures under COVID-19.	Positive
8	Rasheed *et al.*	2021	Saudi Arabia	76	Low	Questionnaire for determine: expectations, skills, views and people thoughts.	Positive
9	Sá *et al.*	2020	Brazil	54	Low	Survey to understand how families were adjusting their daily routines in Covid-19.	Negative
10	Shin; Cho e Kim	2021	South Korea	45	Low	They developed five augmented reality games that provided new possibilities to connect teachers and students.	Positive
11	Samayoa *et al.*	2021	United States	18	High	An instructor performing some workout exercises via the Holographic tool.	Positive
12	Yücekaya *et al.*	2021	Turkey	59	Low	Youtube videos with the title of PE at a Distance and Sports Class were analyzed.	Positive
13	Tel	2021	Turkey	151	High	Research done with athletes about the types of games they played.	Positive
14	Hammami *et al.*	2020	United Kingdom, Tunisia and Iceland	31	Low	This study uses specific recommendations for home physical training.	Positive
15	Cherkasov; Cherkasova e Pestryakov	2021	Russia	34	Low	Article with the aim of carrying out PE by young footballers in pandemic conditions.	Neutral
16	Franco *et al.*	2021	Spain	50	Low	Questionnaire to analyze the effect that a SEM intervention had on the motivational results of different students in the PE class.	Positive

3. Discussion of Results

In this section, the works that were selected based on the SRL methodology used in this document will be presented. A more comprehensive discussion of the summary performed in the Table will be carried out for each of the 16 articles read. The summarized results of each discussion for each published paper are shown in Figure 6.

The study (Bhinder *et al.*, 2021) was conducted in Ukraine in 2021, with 156 first-year cadets considering the Higher Military Educational, using the country's traditional sports to see the reactions after the PA. A survey revealed which sports and how it was for them to participate in these activities. The choice of games to design the special program of implementation of psycho-pedagogy technology, but at the same time they combined different activities like icebreakers, exercises to develop physical strength and exercises with little physical activity. Results confirmed that games helped cadets improve social interaction; increase emotional stability and physique resistance; change attitudes towards themselves and build an optimistic vision; improve adaptability to the existing situation, extreme or special conditions in particular (Figure 6(a)).

According to (Benzing *et al.*, 2021) an international online survey with 13881 adult participants from 18 countries/regions was conducted in 2021 during the pandemic: Austria, Brazil, China, Finland, Germany, Greece, Iceland, Iran, Italy, Malaysia, Philippines, Russia, Spain, Taiwan, Turkey, United Kingdom, United States of America, and Switzerland. The study was conducted in order to understand a relationship between

some basic information and data about the moment of physical activity. So, to analyze the data together, they used an artificial intelligence application in which they used the statistical statistics of tests to predict physical inactivity from the type of exercise that was performed. After analyzing the information by the application, the result was negative, as there was a lot of downtime during the pandemic (see Figure 6(b)).

(a) ID 01.	(b) ID 02.	(c) ID 03.	(d) ID 04.	(e) ID 05.	(f) ID 06.	(g) ID 07.	(h) ID 08.

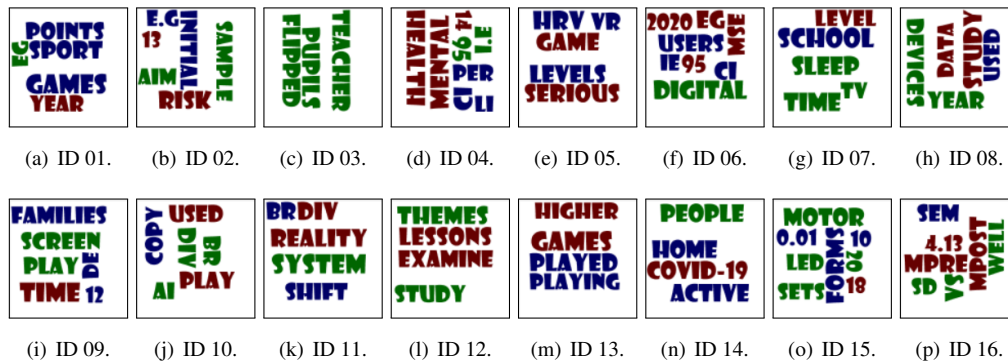| (i) ID 09.	(j) ID 10.	(k) ID 11.	(l) ID 12.	(m) ID 13.	(n) ID 14.	(o) ID 15.	(p) ID 16.

Figure 6. Cloud of words resulted from each paper read in the systematic review.

The study (Petrusic e Stemberger, 2021) was carried out in Slovenia 2021. In total, the PA was measured with 198 pupils aged 12 years old or more, in a survey made to know PE teaching models had the highest participation of people during the Covid-19 for students to achieve high levels of PA. Authors used technology to collect means of intensity level of student PA that were used to predict the result and 6 accelerometers.[†]Authors concluded that distance education is of concern, so schools must prepare to conduct effective distance learning classes to have a positive outcome. Therefore, in the future, it is necessary to discover the effectiveness of new distance learning models for PE, in order to expand the current research (see Figure 6(c)).

The article (Nie *et al.*, 2021) was conducted in China in 2021, considering 14715 participants in total. Through an application by a questionnaire, participants were asked to recall specific influences on their mental health during the pandemic, as well as specific changes in anxiety, fear, depression, somatization, and stress before and after PA. The timely and comprehensive online learning strategy adopted by the Chinese government has alleviated some of the stress and anxiety caused by the suspension of face-to-face classes. PA had significant positive effects in reducing mental health burden, including somatization, anxiety, depression, stress and fear, for all age groups, as well as showing that PA improved mindsets during the pandemic (see Figure 6(d)).

The study (Rodrigues; Postolache e Cercas, 2021) was held in Switzerland in 2021 in which the authors study the effects of Game Exergames on cardiac variability and how they can affect the physical and cognitive performance of 5 adult participants aged between $22 - 26$ years. The authors used an application to integrate the ECG data (electrocardiogram), in relation to the mean age of the participants involved and the absence of health problems. The effort applied in the most demanding session of the game was probably at the cognitive level, where a greater amount of stimuli and the need for less reaction time to complete the game's objectives required greater levels of concentration and good synchronization between PA and movements of both members. When considering the elderly population or rehabilitation people, the physical effort will be much greater, as will the inherent upper musculoskeletal pain (see Figure 6(e)).

The paper (Parker *et al.*, 2021) was carried out in Australia in 2020, a

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[†]MMOXX1.07 , USB $35 \times 35 \times 10$ mm waterproof PA sensor, considered a measuring instrument.

questionnaire called "Our Life at Home" was used, which participants had to answer questions about PA frequency per week and whether participants were using any digital platform to guide in PA. The total number of participants was 14764 individuals, however, only 1188 adults and 963 adolescents provided complete data on adherence to the PA guidelines and digital platform and were included in the analyses. According to the authors, the 6 types of platforms were used: (a) Streaming services for exercises (YouTube, Instagram and Facebook), (b) fitness programs for subscribers, through an app or online (Centr and MyFitnessPal), (c) online classes facilitated live or recorded such as dance, sports training and fitness class through digital platforms (Zoom or Meet), (d) specific apps for sports or activities developed by sports organizations for participants to maintain their skills (TeamBuildr), (e) active electronic games (Xbox Kinect) and (f) online or digital training or racing platforms (Zwift, FullGaz and Rouvy). The results were positive, in particular through streaming services and games (see Figure 6(f)).

The study (Kim *et al.*, 2021) was held in Korea, 217 parents participating, during pandemic related school closures, may cause harmful health and social consequences for children and increase the burden for the family. The study identified parental concerns about children's media use and parents' level of stress or depression positively associated with problem behaviors, exposure and sleep problems, and lack of PA in children. The media used was K-CURE.[‡] Media use was assessed by asking daytime primary caregivers to report the frequency of their children's use of media devices (TV, Tablet, PC and Smartphone). During school closure, children gained body weight, spent less time in PA and more in media usage. Besides online learning content (97.2%), YouTube was highly used content (87.6%), and games followed (78.3%), see Figure 6(g).

In work of (Rasheed *et al.*, 2021) was conducted in Saudi Arabia in 2021, a questionnaire was used with female students to determine: expectations; skills; opinions and thoughts of a total of 24 participants, divided into two groups (12 experimental study and 12 control group), with an additional 8 students to participate in the pilot study measures. Manipulated videos were used to improve PA, after participants answered the questionnaire. The result was that online video games are useful in helping students to acquire various skills to satisfy their needs and promote their engagement, for a normal social life. Students showed positive psychological results with physical fitness. Experimental group attained higher mean scores than students in control group in the study variables. The study concluded that technology devices can be used for PA and can be very effective in the teaching and learning process of PE courses (see Figure 6(h)).

The research (Sá *et al.*, 2020) was carried out in Brazil and published in 2021, with a total of 816 children participating. A questionnaire was created based on LimeSurvey,[§] to assess how families with children from zero to 12 years old were dealing with the confinement due to the Covid-19. This questionnaire was prepared by a committee of experts in the field and tested in 15 families (pre-test). After adjustments in the presentation of the answers in relation to the number of hours of activities performed by the children. The result was that there was a decrease in time spent on PA and an increase in time spent with family and TV (see Figure 6(i)).

The study (Shin; Cho e Kim, 2021) was held in Korea on July 11, 2021. Authors proposed Jumple a virtual room for the EP. Thus, the application allows students to play in a remote learning environment. Artificial Intelligence (AI) pose estimation technology is used to detect the position of body parts and provide real-time feedback, and 5 augmented virtual reality (AVR) games were developed that provided new possibilities to connect

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[‡] Kids Cohort for Understanding of Internet Addiction Risk Factors in Early Childhood.
[§] A free software for the application of online questionnaires that can use databases for persistence.

teachers and students, they are: (1) Catching Stars (develop physical agility), (2) Pop all the Balloons (to motivate students with less physical fitness), (3) Volleyball (developing physical agility), (4) Naming Body Parts (Knowledge of English words) (5) Volleyball 2-players (developing competition and collaboration). The results achieved were positive and showed how teachers engage students in PA in an online space and can generate PA by appealing to students' interests (see Figure 6(j)).

The article (Samayoa *et al.*, 2021) was carried out in the United States of America in 2021. In total, 32 participants between 20 and 24 years old participated in the research. In this case, the paper involved holographic display, AVR and remote collaboration. In this case, Microsoft Azure Kinect was used to capture point from a 3D physical object and a training instructor performed some training exercises through the holographic videos for the students to repeat, considering a boxing mini-game. The authors claim that participants liked and felt motivated especially when using 3D figures and having had PA activities during the lockdown (see Figure 6(k)).

The research (Yücekaya *et al.*, 2021) was made in Turkey, published on April 5, 2021 during the pandemic. In this work, the authors analyzed videos posted on YouTube, considering the title of distance PE and sports classes. The videos chosen were between the years 2019 to 2020. Content analysis of the videos about the PE course in the distance modality on YouTube was carried out. Authors used videos uploaded under the title of PE and PEC in distance education on YouTube. Authors concluded that students were supported with information within the scope of "health-sports" about what they should do to protect their health. In addition, the authors observed that teachers tried to make the process fun through educational games during their stay at home (see Figure 6(l)).

The study (Tel, 2021) was published on December 12, 2021 in Turkey, during the pandemic. The research group consisted of 1521 (927 men and 594 women) athletes. The research aimed to determine the athletes' view of digital games during the pandemic process. A questionnaire was used for each participant and data analysis was performed using the Statistical Package for the Social Sciences (SPSS). Considering the relationship between the age group of athletes participating in the study and the types of games, the rate of strategy games increased with age, and young people between 21 and 30 years old played war games at higher rates. Furthermore, considering the sport level of the participants and the types of games they played, it was determined that the coaches preferred sports and strategy games at higher rates. The result was that encouraging sports activities by preventing inactivity at home during the pandemic process will positively affect people's health (see Figure 6(m)).

The article (Hammami *et al.*, 2020) was done in the UK, Tunisia and Iceland, was published April 20, 2020. This study is based on specific recommendations for physical training at home. Some examples of aerobic exercise, zumba dancing, guided audiovisual gymnastics and aerobic exercise training can be recommended for maintenance of cardiovascular, metabolic and musculoskeletal fitness. Workouts were controlled with heart rate monitoring applications or power load applications. The authors argue that active video games are very popular and some games that involve movement can increase physical activity levels enough to impact health and fitness. Energy expenditure during active video games is comparable to moderate-intensity walking, and for children who spend a lot of time playing online games, PA games appear to be a safe, fun, and valuable means of promoting energy expenditure. These results show that physical activity indoors during the pandemic can positively help a person stay healthy and fit (see Figure 6(n)).

In (Cherkasov; Cherkasova e Pestryakov, 2021) the pandemic was carried out in Russia in 2021. There were 137 students and professionals, 27 philology students,

50 professional editors and writers, as well as members during the VK Linguistics Group. There were 18 boys aged between $9-10$ that were football club members. The article deals with the issue of PE by young footballers in pandemic conditions, to assess flexibility and coordination through a game. A video was prepared accompanied by methodological guidelines. The analysis of the physical capacity was made by technologies and devices of determination of the physical capacity and increase of the flexibility. Negative trends of indicators on average were found in tests of general endurance, speed and coordination skills. Otherwise, competitive gaming methods in the form of remote contact with team members can stimulate an increase in motivation for independent PE. Thus, the approach was considered neutral after reading, as it contains positive and negative points listed by the authors after our reading (see Figure 6(o)).

Finally, in (Franco $et\ al.$, 2021) was carried out in Spain during the pandemic considering 50 participants aged between $14-15$ years, in which they were divided into 2 groups (control group and intervention group). A survey was done, the questions were asked as an incentive. The objective was to analyze the effect that the Sport Education Model (SEM) developed in the Covid-19 scenario had on the motivational results of different students in the PE class. SPSS software was used to process the test data. When students used SEM, they could improve their autonomy, competence and satisfaction of relationship needs, enhancing students' behavioral engagement. According to the authors, is a valid methodological approach to improve positive motivational patterns among students in the context of PE (see Figure 6(p)).

4. Conclusions and future work

With the arrival of the pandemic, significant changes were necessary in people's lives, especially in the area of PE and healthy. Because of this, many sectors within this area have decided to surrender to the digital world. Consequently, there has been a significant development in technology for the advancement of teaching and learning. So that people did not have physical inactivity within the lockdown, tools were created with the purpose of generating performance and motivation for individuals of all ages. The benefits were associated with games and applications of physical activity, which generated another look at distance education, which updated the way of teaching and improved its quality, regardless of its area. The weaknesses brought the lack of research within technology in the area of PE in schools, as most of the articles were applied in non-school, but teaching places, and the increase in the interruption of school practices and physical activities that generated a halt in the physical health of the population. The tools suggested herein can also collaborate with post-pandemic PE classes, helping teachers to motivate their students to practice PA. For future studies, it is necessary to focus more on schools within the area of PE, so that the population can have an improvement in the quality of life and can gain more motivation for external physical activity practices.

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