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Serious Video Games to Keep the Functional Autonomy in Elderly: A Systematic Revision

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Abstract: The use of video games and motion capture systems to maintain functional autonomy in older people is becoming increasingly significant, as they contribute to improving quality of life. The objective was to carry out a systematic review to identify the usefulness of serious video games in maintaining functional autonomy in older adults and to understand the technologies used for the analysis of their movements and the body parts that have been worked on in order to maintain functionality in the performance of their instrumental activities of daily living. The systematic review was based on the criteria proposed by the PRISMA method, and searches were carried out using the following databases: Scopus, PubMed, and IEEEXplore. In the basic search, criteria such as the use of video games, motion capture technologies, and functional autonomy in older adults were taken into account. The search was limited to open access publications published in the period 2015 to 2023, and 153 documents were analyzed, leaving 91; subsequently, 62 that did not meet the inclusion criteria were eliminated, ending with 30 articles that were directly related to the study topic. Among the findings, it was found that the creation of serious video games for older adults was aimed at multiple fields where commercial technologies prevail, which, due to

their low cost, allows the interaction and implementation of gamified activities to improve the quality of life of older adults. Therefore, the work reported on the use of inertial measurement units was 12%, using the Microsoft Kinect sensor 70%, and other technologies 18%. All of these were used as motion capture systems. On the other hand, the two video games reported in the aforementioned articles showed that 20% were commercial products, whereas 80% were self-developed. The novelties that emerged through the analysis of research work were the report of a large number of studies, 70% of which focused on the objective of maintaining balance, coordination, strength, and psychophysiological postural parameters in the elderly, and the additional 30% corresponded closely to the field of physical rehabilitation. Additionally, the implementation of serious video games in older adults allows for active participation in physical activity, leaving aside conventional methods. Therefore, improvements are given from the creation of serious video games and application of mini-games, taking into account the individuality of each adult, as well as the needs, interests, and capacities, thereby achieving mental, emotional, and social balance.

Keywords: elderly; serious video games; exergames; functional autonomy

严肃电子游戏对保持老年人功能自主性的系统性修订

摘要：使用视频游戏和动作捕捉系统来维持老年人的功能自主性正变得越来越重要，因为它们有助于提高生活质量。目的是进行系统评价，以确定严肃视频游戏在维持老年人功能自主性方面的实用性，并了解用于分析他们的动作的技术以及为维持其日常生活工具性活动功能而进行的身体部位训练。系统评价基于PRISMA方法提出的标准，并使用以下数据库进行搜索：斯高帕斯、PubMed和IEEEXplore。在基本搜索中，考虑了诸如视频游戏的使用、动作捕捉技术和老年人的功能自主性等标准。搜索仅限于2015年至2023年期间发表的开放获取作品，分析了153篇文献，剩下91篇；随后，62篇不符合纳入标准的论文被淘汰，最后剩下30篇与研究主题直接相关的文章。在研究结果中，我们发现，为老年人开发严肃电子游戏的目标市场是商业技术占主导地位的多个领域，由于这些技术成本低廉，因此可以通过游戏化活动的互动和实施来改善老年人的生活质量。因此，使用惯性测量单元的工作报告为12%，使用微软Kinect传感器的工作报告为70%，其他技术的工作报告为18%。所有这些都用作动作捕捉系统。另一方面，上述文章中报道的两款视频游戏显示，20%是商业产品，而80%是自主开发的。通过对研究工作的分析发现的新颖之处在于，报告了大量研究，其中70%的研究侧重于保持老年人的平衡、协调、力量和心理生理姿势参数的目标，另外30%与身体康复领域密切相关。此外，在老年人中实施严肃电子游戏可以让他们积极参与体育活动，摆脱传统方法。因此，从严肃电子游戏的创作和小游戏的应用方面给予改进，考虑到每个成年人的个性，以及需求、兴趣和能力，从而实现心理、情感和社会的平衡。

关键词：老年人、严肃视频游戏、运动游戏、功能自主

1. Introduction

In recent years, technological advances have manifested that serious video games, together with exergames created mainly for the elderly, are used as strategies in the educational and investigative fields aimed at maintaining functional autonomy in the elderly. In the context of serious videogames, different categories seek to promote physical activity through the use of different role games. Having said that, multiple studies with the elderly have deepened in aspects of management and user experience proposed by exergames in different sports, showing positive results in the combination of elements for physical exercise with entertainment, in which the elderly generally tend to improve different behavior attitudes, keep themselves physically active, and have a positive and fun perception towards the games [1]. The goal of this study was to perform a systematic revision 3 that allows the identification of the utility of serious videogames to maintain functional autonomy in the elderly, to know the technologies used for the analysis of their movements and the body parts that have been worked on, and to maintain functionality in the development of their daily instrumental tasks.

Following the latter, the World Health Organization [2] considers any man or woman who is over 60 years old as elderly; this is a physiological process of dynamic, gradual, natural, and inevitable aging, which develops in the biological, psychic, and social aspects of the elderly, and is structured around the passing of time. Now, if it is taken into account that autonomy is a personal state contrary to dependence, it can be defined as the ability of a person to do all of the daily activities in an independent way that allow him or her to adapt to his or her surroundings and perform his or her social role. Broadening this concept, it can be said that according to [3], the functional autonomy in elderly is the ability of the individual to perform, in an independent way, the daily life activities such as feeding, dressing, mobility, decision making and effective communication. Likewise, as acknowledged in [4], functional autonomy is one of the most relevant concepts in relation to health, physical aptitude, and quality of life. On the other hand, for the dependent elderly, the process for achieving autonomy is slower or never accomplished in any aspect at all. Therefore, in this group of people, it is fundamental to develop programs with the goal of achieving basic personal autonomy. Similar to [5], the use of exergames has shown positive results to incentivize the elderly to increase their motivation towards physical health and rehabilitation. These games tend to offer ludic routines that require players to perform movements involving their entire body to interact with the game [4]. Therefore, although in recent years interest in designing technological proposals focused on supporting the processes of functional autonomy in the elderly has increased, it has been difficult and not very dynamic, having, as a result, difficulties and gaps in the area of knowledge of technological innovation. Becoming into an improvement opportunity and, based on that, contributes to aspects associated with obtaining biomechanical information, covering serious videogames offered to the elderly [6].

2. Materials and Methods

In this section, we describe the process and criteria taken into account for selecting the articles included in this documentary research work based on the characteristics of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) method [7], which allows the identification, selection, and critical assessment of future research priorities, as well as collecting and analyzing data from the research publications included in the revision.

2.1. Eligibility Criteria

The eligibility criteria considered for the addition of research publications in this revision were: i) documents published in the English language, ii) documents published from 2015 to 2023, and iii) types of documents: scientific articles and conferences. In terms of criterion (ii), it was selected this period of time, given that since 2010, with the arrival of the Kinect sensor and until 2015, its functions gained popularity in different contexts, but after 2015, it is notorious the rise of enterprises and proposals that, apart from the Kinect sensor, use other motion capture systems and join serious videogames in the field of physical condition in the elderly, which is the main interest of the research. Another important element in this revision is the fact that the five selected studies had the purpose of maintaining functional autonomy, coordination, strength, equilibrium, and psychophysical postural parameters using serious videogames and/or a motion capture system, which is of great relevance to the age of the population who participated in the approval of the mentioned proposals.

2.2. Search Strategy

The search for published articles was performed using the following academic databases: Scopus, PubMed, and IEEEXplore. The keywords used were classified into the following groups: (1) physical ability: coordination, balance, strength, flexibility, gait, speed, accuracy, motivation, motor skills, power, attention, memory, physical conditioning, physical activity, joint movement patterns, body functions and activities, cognitive motor skills, visual auditory ability, range of motion, standard psychomotor rehabilitation, musculoskeletal function, and psychophysiological parameters. (2) In terms of the use of videogames the keywords were: videogames, ‘video games,’ video-games, ‘serious videogames’, ‘serious games’, ‘serious video games,’ exergames, exergaming, ‘active videogames’; (3) the words used referring to the motion capture technology were: ‘inertial sensor, ‘ ‘motion capture,’ mocap, ‘motion capture system,’ wearable; and (4) the keywords based on the body part where the functional autonomy was potentialized were: ‘upper limb,’ elbow, shoulder, arms, spine, wrist, subassembly of joints and lower limbs: Hip, Thigh, Knees, Leg, Ankle, foot.

Thus, the search parameters used in the databases (see Table 1), in each of the groups, internally included the OR operator among the different keywords considered as synonyms, and as a group separator, the AND operator was used to lead the search to include at least one keyword from every relevant group in the information search.

2.3. Description of the Process for Selecting the Research Publications

The process of selection of the research publications, based on the revision topic, mainly includes four stages, starting by identifying the

research, in this task it is taken into account the total register that respond to the search parameters in every database. The second stage focuses on applying filters following the eligibility criteria to select the publications related to the revision purposes that are available. The third stage called "screening" allows to filter the publications, discarding the ones that are not adjusted to the research focus and/or the ones that are duplicated in the different databases. Finally, the inclusion stage allows the identification of only those documents that will take part in a detailed analysis of the systematic revision.

Table 1. Search parameters in the different databases (The authors' elaboration)

Database	Search Parameters
Scopus	TITLE-ABS-KEY (Quality of life OR Virtual reality OR Well-being360° video OR elderly OR immersive virtual reality OR mental health OR well-being older adults OR physical/mental health OR psychology; scoping review OR virtual reality Accessibility OR Older adults; Physical activity; Virtual reality Ageing OR Computer-mediated OR communication; Game-mediated communication OR Game-playing OR Information OR communications technology; Skills; Social dynamics coordination, OR Augmented Reality OR Digital Inclusion OR Elderly People OR Opinion OR Technology Acceptance Model OR Virtual Reality OR Immersive Technology OR Mixed Reality OR Senior Citizens OR Virtual Reality balance, OR "strength" OR "flexibility", OR "gait", OR "speed", "accuracy", OR "motivation" OR "motor skills", OR "power", OR "attention" OR "memory", OR "physical conditioning," OR "physical activity", OR "joint movement" OR "patterns", OR "body functions" OR "activities, cognitive" motor skills, visual auditory ability, range of motion, standard psychomotor rehabilitation, musculoskeletal function, psychophysiological parameters AND (videogames OR "video games" OR "video-games" OR "serious videogames" OR "serious games" OR "serious video games" OR "exergames" OR "exergaming" OR "active videogames") AND ("upper limb" OR "elbow" OR "shoulder" OR "arm" OR "wrist" OR "humerus") AND ("inertial sensor" OR "motion capture" OR "motion capture system" OR mocap OR wearable) AND (LIMIT-TO (PUBYEAR, 2023) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (7 PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015).
PubMed	Coordination OR balance, OR "strength" OR "flexibility", OR "gait", OR "speed", "accuracy", OR "motivation" OR "motor skills", OR "power", OR "attention" OR "memory", OR "physical conditioning," OR "physical activity", OR "joint movement" OR "patterns", OR "body functions" OR "activities, cognitive" motor skills, visual auditory ability, range of motion, standard psychomotor rehabilitation, musculoskeletal function, psychophysiological parameters AND (videogames OR "video games" OR "video-games" OR "serious videogames" OR "serious games" OR "serious video games" OR "exergames" OR "exergaming" OR "active videogames") AND ("upper limb" OR "elbow" OR "shoulder" OR "arm" OR "wrist" OR "humerus") AND ("inertial sensor" OR "motion capture" OR "motion capture system" OR mocap OR wearable)).
IEEE Xplore	(coordination OR balance, OR "strength" OR "flexibility", OR "gait", OR "speed", "accuracy", OR "motivation" OR "motor skills", OR "power", OR "attention" OR "memory", OR "physical conditioning," OR "physical activity", OR "joint movement" OR "patterns", OR "body functions" OR "activities, cognitive" motor skills, visual auditory ability, range of motion, standard psychomotor rehabilitation, musculoskeletal function, psychophysiological parameters (videogames OR 'video AND games' OR video-games OR 'serious AND videogames' OR 'serious AND games' OR 'serious AND video AND games' OR exergames OR exergaming OR 'active AND videogames') AND ('upper AND limb' OR 'elbow' OR 'shoulder' OR 'arms' OR 'wrist' 8 OR 'Knees) AND ('inertial AND sensor' OR 'motion AND capture' OR 'mocap' OR 'motion AND capture AND system' OR wearable)).

3. Results and Discussion

In this section, we present the findings from the application of the process of selection of research publications as well as the characteristics of the studies included in the analysis and the individual results exposed to those publications.

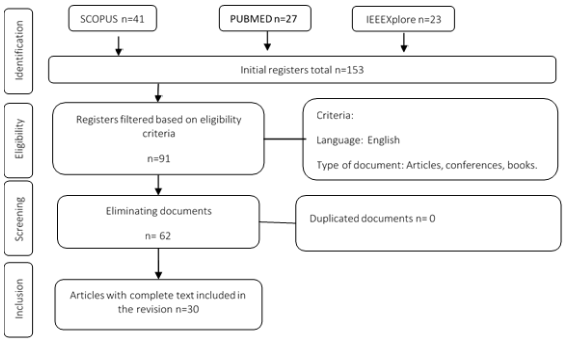

Figure 1. Systematic process used in the articles' selection, based on PRISMA (The authors' elaboration)

3.1. Selection of Research Words

Figure 1 presents the systematic process to select the articles checked by pairs, in which 153 documents were identified in the databases, published from 2015 to 2023, which included the keywords. Essentially, these publications are focused on supporting the processes to maintain functional autonomy in the elderly by using serious videogames and/or motion capture systems. From the latter total, after applying the eligibility criteria mentioned before there were 91 publications, to be reduced afterwards to 30 documents directly related to the topic of study in this revision by eliminating the ones that did not follow the inclusion criteria.

3.2. General Characteristics of the Research Publications

The main characteristics of the 30 studies included in the revision, based on the focus of this research, can be classified into three groups: i) according to the technology of the serious videogames and the motion capture system used, ii) according to the indicators of functional autonomy in the elderly, which is the focus of this research, and iii) availability of the technology used in this research, as shown in Figure 2.

Figure 2. Use of motion capture systems (MOCAP) (The authors' elaboration)

Regarding the use of motion capture systems, there is a 70% Microsoft Kinect from consoles such as Xbox, Microsoft speech, removal system, Minilab LISREL custom system, Jintronix technology, virtual reality, and motion sensors modified for applications, mini games, etc. IMU measurements, such as Kinoptim, hocamose Vet, RGB cameras, support vector machines, marker-based 3D motion capture systems, depth sensors are equivalent to 12%; and other technologies, its percentage is set at 18% from Nintendo Wii (Balance Board), Infrared, Bluetooth modules, commercial applications modified for specific purposes, and other technologies.

3.2.1. Functional Autonomy Indicators

In the analyzed studies, it was identified that 70% of the research publications were focused on maintaining equilibrium, eye-hand coordination, strength, motion, psychophysical postural parameters, body functions and activities, functional ability and motivation for physical activity, visual and auditive ability, range of motion, speed, precision, standard psychomotor rehabilitation, musculoskeletal function, motion abilities, attention, and memory. 12%, report the support in keeping the coordination, equilibrium and strength, and the other 18 % report the contribution to articular movement patterns, physical conditioning, motor abilities, equilibrium strength-gait (See Figure 3).

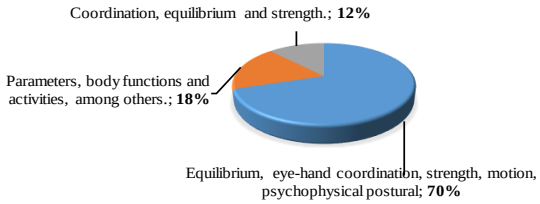

Figure 3. Functional autonomy indicators (The authors' elaboration)

3.2.2. Availability of the Used Technology

Regarding the availability and accessibility of the technology, 30% of the publications included in this revision used commercial products focused on maintaining the physical condition of functional autonomy. Fifty% of the publications present the proposed systems, which means that they refer to technology development in academic and/or research environments. 20% have been classified as "Mixed," due to the fact of the used technology involves the mix between commercial products and any kind of personalized development (mainly videogames) as seen in the Figure 4.

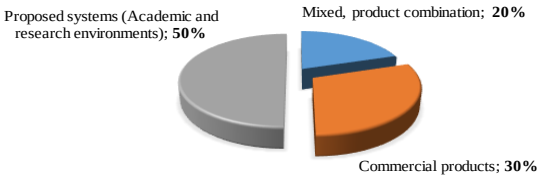

Figure 4. Distribution of the technology used (The authors' elaboration)

An additional aspect in the global analysis of research publications is that, whereas in the search parameters, it included general functional autonomy and body composition, it was also identified that 50% addressed in a general way the upper limbs (arms, shoulders, spine, hands, wrist, etc.) and the other 50% addressed the lower limbs (knees, legs, ankles, and feet).

3.2.3. Technologies as Support to the Functional Autonomy in Elderly

In Table 2, the main characteristics of each of the 30 analyzed publications are presented, along with the way in which these publications support the functional autonomy processes by using videogames and motion capture systems.

Table 2. Characteristics of the research publications analyzed in the revision (The authors' elaboration)

Ref.	MoCap System	Physical ability	Population (sample)*	Used technology (commercial and/or developed)	Involved body part
[8]	IMU Kinoptim	Coordination, Equilibrium, Strength	8 P	The system KINOPTIM uses the following hardware	Arms, Knees, Legs

				devices: 4 IMU's, an RGB camera, a Depth sensor, a work station and a monitor.	
[9]	MS Kinect	Equilibrium	20 P	Mixed: MS Hololens and developed video game	Shoulders, Spine Right knee
[10]	IMU Hocamose-vets	Physical conditioning	XP	Proposed system: Fitness Digital game	Upper and lower limbs with subassembly of joints
[11]	IMU	Joint movement patterns	12 P	Mixed: Random Forest (RF), vectors machine for support, k-closest neighbors and MultiLayers Perceptron (MLP) (3D motion capture systems based on markers)	Upper and lower limbs with subassembly of joints
[12]	MS Kinect	Equilibrium, Coordination, Speed, Functional Autonomy	30 P	Commercial: MS Kinect V2	Upper and lower limbs
[13]	IMU	Motor abilities	55 P	Mixed: The software was designed in language C and the Unit for the platform Unity (Asset Store) and 3DMax. Mini game "Cross Fun Plane" Red Ball Game.	Upper limbs
[14]	Nintendo Wii Balance Board	Physical activity and physical literacy	40 P	Mixed: Nintendo Wii -Fitbit flex Tm	Upper and lower limbs
[15]	MS Kinect	Functional ability and motivation	23 P	Commercial: MS Kinect V2 and videogame linked to the Kinect	Upper and lower limbs
[16]	MS Kinect	Physical Activity	17 P	Mixed: MS Kinect and Framework Microsoft Speech SDK, Microsoft Azure Kinect DK TM.	Upper and lower limbs
[17]	MS Kinect	Motor cognitive abilities	13 P	Mixed: MS Kinect and preliminary study of possible use of Remove System, Lot System, Microsoft Kinect V2, Leap Motion and Touchscreen.	Upper and lower limbs
[18]	MS Kinect	Physical Activity Visual-auditive Ability	39 P	Mixed: MS Kinect and development of a personalized system Minilab y LISREL	Upper and lower limbs
[19]	MS Kinect	Range of motion, Speed, Accuracy, Equilibrium	48 P	Mixed: Ms Kinect and Jintronix technology	Upper and lower limbs
[20]	Nintendo Wii	Walking speed, Equilibrium, Fragility	80 P	Commercial: Nintendo Wii	Upper and lower limbs
[21]	MS Kinect	Standard psychomotor rehabilitation	50 P	Commercial: Games platform medimoov.	Upper and lower limbs
[22]	MS Kinect	Equilibrium	12 P	Kinect	Upper and lower limbs
[23]	MS Kinect	Equilibrium and Motion	31 P	Proposed system Motion Rehab AVE 3D	Upper limbs
[24]	MS Kinect	Musculoskeletal Function	90 P	Mixed: MS Kinect and Program Gpower 3,19	Upper and lower limbs
[25]	MS Kinect	Strength, Power	125 P	Mixed: Monitor Wii Fit plus games	Hand
[26]	MS Kinect	Postural and psychophysical parameters	24 P	Virtual Reality (Intelligence and innovations Rusia)	Upper limbs
[27]	MS Kinect	Equilibrium	36 P	Proposed system	Lower limbs
[28]	MS Kinect	Equilibrium, Motor abilities, Attention Memory	30 P	Videogames platform	Upper and lower limbs
[29]	Ms Kinect	Equilibrium and functional mobility	5 P	Software kinectlabs 3D	Upper and lower limbs
[30]	MS Kinect	Speed, Attention and Memory	40 P	Mixed: Videogame Sport Resort	Upper and lower limbs
[31]	MS Kinect Xbox	Motor Activity	40 P	Mixed: Mini game Kinect Sports	Upper and lower limbs
[32]	Nintendo Wi Fit	Equilibrium and daily	--	Nintendo Wii Balance Board	Upper and lower

		life activities		Wii Sports	limbs
[33]	IMU	Motor mobility	26 P	Mixed: Platform Unity 3D	Upper limbs
[34]	MS Kinect	Shoulder flexibility Heart rate	23 P	Mixed: Exergames compatible with WBB, accessory Wii Bowling	Upper limbs
[35]	Nintendo Wii	Equilibrium, Coordination, Strength Flexibility	40 P	Mixed: Balance Board	Upper and lower limbs
[36]	MS Kinect	Strength	10 P	Mixed: Unity Engine, videogame: Kineactiv	Upper limbs
[37]	MS Kinect	Functional Equilibrium Posturography	75 P	MS Kinect	Upper and lower limbs

The aging process in the elderly turns out to be an indicator to be taken into account in the development and use of videogames in this population, given that, with this, it is aimed at maintaining physical and mental benefits. This article performs a general revision in recent years, focusing on the technologies, devices, and systems used for the implementation of serious videogames in the elderly. The research publications included in this revision show differences between commercial motion capture systems and self-developed systems.

According to [38], interventions through serious videogames have shown improvement in equilibrium, functional mobility, muscular strength, proprioception, and cognitive function, which have an impact on the performance associated with motor control, which directly affects functional independence in this age range, thus showing a potential effect on the quality of life in the elderly. This was observed in interventions of 3, 6, and 8 weeks, showing a good adherence to the game with Xbox, Kinect, and Nintendo Wii being a very pleasant experience, thus showing its effect, not only in the adherence but also in the motivation of the users in the functional treatments.

In a study performed by [39], the authors approached the design of computer-based games and their effect on functional recovery. Interventions in virtual reality have been a variant of conventional therapies in the elderly, such as PlayStation Move ® from Sony ®, Xbox Kinect ® from Microsoft ®, and Wii ® from Nintendo ® (Smith et. al 2012). The Xbox Kinect ® has proven to be an interesting tool for assessing physical function, used in clinical populations to examine aspects of gait and equilibrium function [40, 41].

3.3. Technologies that Support the Preservation or Rehabilitation of the Functional Autonomy in Elderly

Motion capture (MOCAP) is a movement acquisition process using a combination of software and hardware, and it is understood as a technique of movement recording and its corresponding transformation in a digital model. Its use is common in areas such as entertainment, robotics, medicine, physical rehabilitation, and physical conditioning. The most well-known classification of MOCAP systems was developed in [42], from which its classification as optical and non-optical was analyzed as follows:

3.3.1. Functional Autonomy or Rehabilitation with Optical Systems

In [43] present the following argument, the measurement of human movement with optoelectronic systems offers accuracy based on the position of the retro-reflecting markers; the accuracy of the position of the marker depends greatly on the optical characteristics of the camera system and the algorithms implemented in the tracking software. The Kinect sensor from Microsoft is one of the optical systems for motion capture without markers, which can detect 35 joints of the human body of six people simultaneously and provides accurate information on the depth data.

In this revision, the majority of research publications described the way they involved the Kinect sensor as an optical system for motion capture in the development of the research. On the one hand, they use sensors, and on the other hand, they propose new products to support the processes of functional autonomy in the elderly. For instance, [8] assessed the usability and performance of the Kinoptim system with the goal of monitoring the risk of falling in the elderly. This work includes (4) inertial sensors, an RGB camera, a depth sensor, a work station, and a monitor. Likewise, this research proposes the use of XBOX with a system linked to the joystick of games in Microsoft Kinect V2, and motion capture technology to guide and immerse an avatar in a three-dimensional environment developed in Unity 3D, which supports the processes of functional and motivational ability in the upper and lower limbs. In this regard, [18] used the Kinect sensor and games developed through Kinect sports, with an architecture designed for the elderly, allowing us to verify that serious videogames can be used as a tool to assess the development of motor and cognitive abilities on the whole body and the subassembly of joints to reduce the risk of falling and preserve functional autonomy.

In this manner, [36] established the spatial accuracy and validity of the measurement of the sensor Microsoft Kinect V2, developing Kineactive based on an RGB Depth sensor. The authors proposed an

exergame to motivate the participants to perform the rehabilitation exercises proposed by a specialist, control the performance, and correct execution mistakes on the way.

3.3.2. Functional Autonomy or Rehabilitation with Non-Optical Systems

Diverse publications implement the IMU given the potentialities they offer, that is, the case of the research work presented by [44], in which it is proposed a rehabilitation system that joins videogames and portable technology, and allows the development of exercises at home to help in the recovery in a remote way of patients with a stroke that presents disability in the upper limbs. The developed system has two main components: the environment of the game engine and the software of the therapist to remotely track the progress and achievements of his/her patients. In terms of the proposed hardware for motion capture, a server was implemented in a Raspberry Pi wirelessly linked to a development platform and an sensor MPU6050, a flexible sensor for spotting the flexion and resistance of the fingers, and a pulse sensor to control the heart rate. Through a survey, the authors identified great potential for the developed system to make it easier for the rehabilitation process of patients from the comfort of their home and under the remote supervision of the therapist.

Knowing the advantages of the use of inertial sensors, some publications have focused on improving its performance on one side, and taking into account one of the limiting factors shown by the IMU, which is the drift issue, [45] proposed a drift correction method based on the Rest Pose Magnetometer-based drift correction (RPMC), for the measurement of combined inertia and real-time arm tracking based on the magnetometer. This method corrects the drift while the user is resting based on a recalibrated magnetic field direction.

3.3.3. Null Hypothesis

Serious video games do not improve functional autonomy through motion capture.

3.3.4. Alternative Hypothesis

Serious video games in older adults improve functional autonomy through motion capture.

To recognize the alternative hypothesis, it is necessary to understand that within the context of serious video games, there are ludic strategies that encourage physical activity through different game roles. The implementation of exergames stimulates mobility of the entire body through the use of gamified interactive environments with immersive experiences that simulate different sensations of presence. For this reason, research, such as [46], in older people has delved into aspects of use and user experience proposed by exergames in different scenarios of physical activity practice, yielding positive results in the combination of physical exercise with entertainment, in which older adults in general tend to improve and/or maintain their functional autonomy. Similarly, older adults perceive serious video games as a field of entertainment, well-being, and social integration [1].

4. Conclusion

Based on the importance of physical condition and quality of life in the elderly, in this systematic revision, we identified the technological contribution that has been developed in recent years, mainly in the creation and execution of serious videogames and motion capture systems as a support to maintain functional autonomy in the elderly. In the research publications it is found a broad use of the Kinect sensor as motion capture system, although there are some limiting factors in the movements performed in the depth level and limbs obstruction, it means, the visual interruption between the camera and one of the body parts, as well as data collection in some specific positions and aspects associated to accuracy are placed into consideration with greater emphasis when it deals with functional autonomy where the accuracy can be a crucial factor in the process. However, this sensor has been used as a ludic strategy for strengthening physical abilities such as equilibrium, strength, eye-hand coordination, flexibility, and aerobic skill.

Therefore, the usability of the proposed technologies or the verification of movement assessment methods among commercial products (not only the Kinect sensor from Microsoft but also the Nintendo Wii with its Balance Board, Kinoptim) has allowed for validation in the research field because they have a lower cost compared to advanced systems.

On the other hand, it has been identified that the use of serious videogames in the elderly increases motivation mainly on preservation processes.

In conclusion, the results of this study suggest that the implementation of serious video games in older adults must meet the characteristics of maintaining functional autonomy, responding to the following indicators: use of simple audio-visual material, creation of assessment schemes according to the characteristics of the population, configurability in terms of range of movement, body composition, speed, execution time, identification of the level obtained, and other aspects of the process. Likewise, our findings support the hypothesis that serious video games in older adults significantly improve and/or maintain the physical condition of the population. These results have important implications for the design and application of serious video games aimed at preventing, maintaining,

and/or improving functional autonomy, given that aging is a dynamic and irreversible process. Future research should explore the effects of the implementation of serious video games in older adults through virtual reality accompanied by artificial intelligence and propose an index of functional autonomy.

Declarations

Author Contributions

Conceptualization, M.C.-C. and Y.S.C.; methodology, M.C.-C.; software, A.C.A.-A.; validation, M.C.-C., Y.S.C. and A.C.A.-A.; formal analysis, M.C.-C.; investigation, Y.S.C.; resources, A.C.A.-A.; data curation, M.C.-C.; writing—original draft preparation, Y.S.C.; writing—review and editing, M.C.-C.; visualization, A.C.A.-A.; supervision, M.C.-C.; project administration, M.C.-C.; funding acquisition, Y.S.C. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Universidad Pedagógica y Tecnológica de Colombia.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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