EXERGAMES AND MOTOR LEARNING: SYSTEMATIC REVIEW

EXERGAMES E APPRENDIMENTO MOTORIO: REVISIONE SISTEMATICA

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Double Blind Peer Review

Citazione

Valentini M., Picone V., (2023) Exergames and motor learning: systematic review, Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva - Italian Journal of Health Education, Sports and Inclusive Didactics. Anno 7, V 3. Edizioni Universitarie Romane
FUORI CALL

Doi:
https://doi.org/10.32043/gsd.v7i3.1022

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gsdjournal.it
ISSN: 2532-3296
ISBN: 978-88-6022-483-5

ABSTRACT
Distance learning has led to a reflection on the role of physical activity even with children in nursery and primary schools. The traditional physical space combined with online suggests a rethinking of places and teaching-learning processes. Objective: to understand if and in what way active video games were considered and studied before the pandemic and if exergames can represent a useful teaching strategy to reclaim the priority role of physical activity in the education of the student and a tool for combating overweight, obesity, and sedentary lifestyle. Fixed point: exergames must not replace the physical exercise and movement inherent in the physical and motor education curriculum but integrate them.

La didattica a distanza ha indotto una riflessione sul ruolo dell'attività motoria anche con bambini della Scuola dell'Infanzia e Primaria. Il tradizionale spazio fisico coniugato all'online suggerisce un ripensamento di luoghi e processi di insegnamento-apprendimento. Obiettivo: capire se e in quale modo i videogiochi attivi erano considerati e studiati prima della pandemia e se gli exergames possono rappresentare una strategia didattica utile per rivendicare il ruolo prioritario dell'attività motoria nella formazione dell'alunno e strumento per il contrasto a sovrappeso, obesità e sedentarietà. Punto fermo: gli exergames non devono sostituire l'esercizio fisico ed il movimento insiti nel curricolo dell'educazione fisica e motoria, ma integrarli.

KEYWORDS
Exergames, Children, Physical Education, Systematic review

Exergames, Bambini, Educazione Fisica, Revisione Sistematica

Received 14/11/2023
Accepted 14/11/2023
Published 07/12/2023

Introduction[1]

The World Health Organization recommends an adequate amount of movement, corresponding to at least 60 minutes per day of MVPA (Moderate Vigorous Physical Activity), not only to be physically well but also to foster the development of relational and cognitive skills in children. Physical inactivity has immediate consequences in terms of body constitution but also indirect consequences in terms of building all those elements (in terms of skills and competencies) that are valuable for healthy physical and mental development in adult life. In a holistic view of the Person, motor learning, with its control and transformation of movements, will contribute to the formation of the subject from an early age.

In addition to the movement and exercise inherent in the physical/motor education curriculum, which is a useful strategy for increasingly promoting a healthy lifestyle, is the category of active video games, particularly exergames. They appear to have the potential to increase energy expenditure and motivation in children but it is not yet clear whether they can provide benefits in skill acquisition similar to those found in traditional physical education. They are not "aut-aut" (in the terms of an alternative) but "et-et" (in the terms of a mutual integration). New educational practices hypothesize the inclusion of active video games in the formal context of motor learning. The analysis involves different levels of investigation: perception, enjoyment, competence and skills, active and non-active video games, and different types of AVGs (Nintendo Wii, Xbox Kinect, Dance Dance Revolution). The inclusion of exergames in the formal learning environment of motor education is certainly a richly attractive prospect, but its implications still raise doubts and questions.

[1] The contribution was equally distributed among the authors, of which Manuela Valentini edited the introduction and methodological part; Valeria Picone evaluated the discussion and conclusions.

1. Methodology

The systematic review work was conducted during September-December 2022.

The systematic review was designed, organized, and processed through a procedure consisting of several consequential steps:

1) Choice of topic and formulation of the question
2) Querying of online search engines (ApaPsycarticles, ApaPsycinfo, Eric, Psychology and Behavioral Sciences Collection, Sportdiscus with full text) based on chosen keywords
3) Identification and selection of items for analysis through the application of inclusion and/or exclusion criteria

Inclusion criteria:

- Studies published between 2004 and 2022
- Source types: academic publications, reports, journals
- Full-text
- English language texts
- Age: childhood (birth-12 years)
- Methodology: Empirical study, Quantitative study, Literature review
- Classification: Promotion and maintenance of health and wellness, Cognitive and perceptual development, Psychosocial and personality development, Classroom and dynamics and student adjustment and attitudes, Educational measurement, Sports and Exercise

Exclusion criteria:

- Duplicates
- Age above 10 years
- Inconsistent abstract

4) Retrieval of the full texts of the included studies
5) Summary tables of data extraction for analysis (protocol table)

6) Reading and analysis of selected articles

In developing the review, risk bias (distortion) was considered and mitigated:

- Selection bias: the procedure for including studies followed systematic criteria
- Time bias: scientific publications published between 2004 and 2022, wide time range.
- Language bias: scientific research in English selected from major search engines

STEP FLOW CHART FOR THE SYSTEMATIC REVIEW

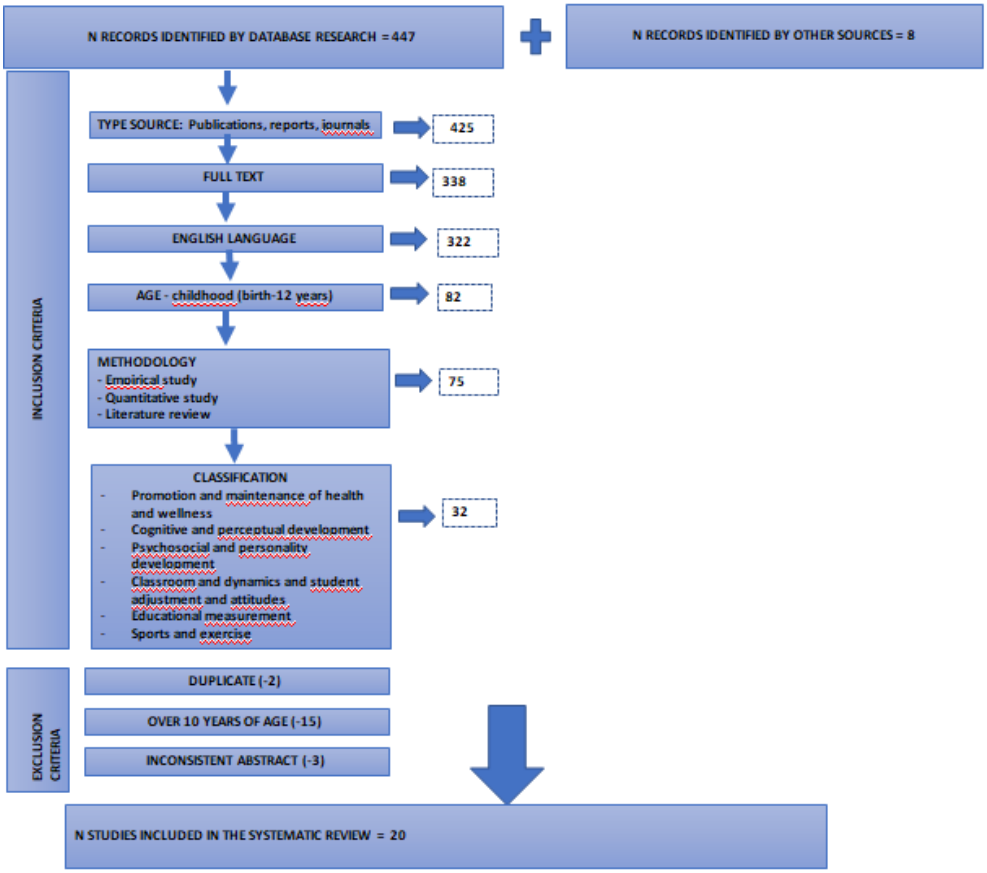

Table 1

The search yielded 20 results.

They include: year 2008 (n=1); year 2010 (n=2); year 2012 (n=1); year 2013 (n=3); year 2014 (n=2); year 2015 (n=3); year 2016 (n=3); year 2017 (n=3); year 2018 (n=2). Of these, 8 in the United States, 2 in Asia, 2 in the Netherlands, 1 in Canada, 3 in Australia, 1 in Greece, 1 in Italy, 1 in Brazil, and 1 in the United Kingdom. Both quantitative (physical tests) and qualitative (surveys, questionnaires) research methods were adopted in the studies considered.

PROTOCOL TABLE

AUTHOR COUNTRY YEAR	TITLE	SOURCE	SEARCH ENGINE - KEYWORDS	CHAMPION	PURPOSE	RESULTS
Marijke J. M. Chin A Pawa et al., Holland 2008	The motivation of children to play an active video game	Journal of Science and Medicine in Sport, Vol 11(2), Apr, 2008. pp. 163-166.	APA PsycInfo motivation, children play behavior, active video games, dance simulation videos, physical activity	n = 27 age = 9-12	Motivation of children to play an interactive dance video game. (multiplayer lesson)	Multiplayer lessons can increase children's motivation
Danielle Levac et al., Canada 2010	Exploring children's movement characteristics during virtual reality video game play	Human Movement Science, Vol 29(6), Dec, 2010. pp. 1023-1038.	APA PsycInfo children, movement characteristics, virtual reality, video games, Nintendo	n = 38 age = 7-12	avg use in pediatric rehabilitation	game experience alone is not the sole determinant of the quantity or quality of movement during play.
Victoria A. Fogelet al, Canada 2010	The effects of exergaming on physical activity among inactive children in a physical education classroom	JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2010, 43, 591-600	Eric childhood obesity, exergaming, physical education, social validity, video games	n = 4 age = 9	Exergames as an aid in physical activity inactive children	The exergaming condition resulted in higher levels of physical activity for all 4 participants compared with the PE condition.
James N Roemmich et al, United States 2012	Autonomy supportive environments and mastery as basic factors to motivate physical activity in children: a controlled laboratory	The International Journal of Behavioral Nutrition and Physical Activity, Vol 9, Feb 21, 2012. ArtID: 16	APA PsycInfo intrinsic motivation, physical activity, autonomy-supported environment, activity intensity, energy expenditure,	n = 44 age = 8-12	Choice and intrinsic motivation can help approach physical activity	An environment that provides both autonomy and mastery is more effective in increasing physical

	study		exercise, health promotion, mastery			activity time. exergame does not promote greater energy expenditure than the same activities performed indoors
Haichun Sun United States 2013	Exergaming Impact on Physical Activity and Interest in Elementary School Children	Physical Education, Recreation, and Dance Vol. 83, No. 2, pp. 212-220	Eric calories expenditure, physical education, situational interest	n = 74 age = 9-12	differences between elementary school physical education students' classroom physical activity and situational interest motivation in an exergame unit and a fitness education unit.	exergaming exerts strong, attractive characteristics that can induce a high level of situational interest motivation. The exergaming unit, however, did not generate enough physical activity.
Zan Gao et al. United States 2013	Examining elementary school children's level of enjoyment of traditional tag games vs. interactive dance games	Psychology, Health & Medicine Sep, 2014, Vol. 19 Issue 5, p605 9p.	SPORTDiscus with Full Text Dance DanceRevolution; gender differences; physical activity enjoyment	n = 326 age = 8-11	omparing the idiom of children in … traditional games	children showed a very high level of interest in interactive dance games compared with tag games
Rita L. Rosa et al, Australia 2013	Development and use of an observation tool for active gaming and	Perceptual and Motor Skills, Vol 117(3), Dec, 2013. pp. 935-	APA PsycInfo Observation Tools of Active Gaming	n = 18 age = 5-8	active video games could improve the acquisition	children showed a lack of body movement While

	movement (OTAGM) to measure children's movement skill components during active video game play	949.	and Movement, psychometrics, test development, test validity, test reliability, movement skill components, video game play, elementary school children		of fundamental movement skills in children, particularly object control skills,	playing the game on Nintendo Wi
Emely De Vet et al, Holland 2014	Dutch children and parents' views on active and non-active video gaming	Health Promotion International, Vol 29(2), Jun, 2014. pp. 235-243.	APA PsycInfo video games; physical activity; children; parents	n = 46 age = 8-12	Talks on preference between active and inactive games	active video games were preferred to inactive video games.
Zan Gao et al, United States 2014	Effects of Exergaming Based Exercise on Urban Children's Physical Activity Participation and Body Composition	Journal of Physical Activity & Health, Vol 11(5), Jul, 2014. pp. 992-998.	APA PsycInfo active video game, aerobic dance, Dance Dance Revolution, percent body fat, underserved children	n = 185 age = 9-12	To examine the impact of an exergaming-based exercise program on the physical activity levels and body composition of urban children. (ed.)	exergaming could have a significantly positive effect on participation. the long-term effect of the program on children's body composition deserves further investigation.
Nikolaos Vernadakis et al, Greece 2015	The impact of an exergame-based intervention on children's fundamental motor skills	In Computers & Education April, 2015 83:90-102	ScienceDirect Active video games, Exergames, Object control skills, Enjoyment, Elementary education	n = 66 age = 6-7	The impact of Xbk exergames on children's object control skills, compared with traditional approaches to developing	the use of the XbK game console as an intervention is a valuable, feasible, and enjoyable approach to improving children's

					these skills	OC skills
Zan Gao et al, United States 2015	A Comparison of Children's Physical Activity Levels. In Physical Education, Recess, and Exergaming.	Sport, Education and Society, Vol 27(1), Jan 2022. pp. 41-56. Journal of Physical Activity & Health, Vol 12(3), Mar, 2015. pp. 349-354.	APA PsycInfo childhood obesity, light physical activity, moderate-to-vigorous physical activity, school-based physical activity programs	n = 144 age = 6-8	Compare ddr levels in physical activity, recreation, exergaming	Confirmed enhanced effectiveness of interval phase and exergaming in promoting MVPA for children
Tara M. Johnsona et al, Australia 2015	Does playing a sports active video game improve young children's ball skill competence?	Journal of Science and Medicine in Sport, Vol 19(5), May, 2016. pp. 432-436.	APA PsycInfo Exergaming Child Motor skills Xbox Fundamental movement skills	n = 36 age = 6-10	avgandobject control.	Playing Xbox Kinect does not significantly affectchildren'sperceived or actual object control abilities
Scott J. Pedersen et al, Australia 2016	Cautionregardingexergames: a skill acquisition perspective	Physical Education & Sport Pedagogy May, 2017. Vol. 22 Issue 3, p246 11p.	SPORTDiscus with Full Text Exergames; skill acquisition; deliberate practice; laterality; children	n = 30 age = 7-12	xergames can lead to the acquisition of skills similar to those in physical education	Deliberate practice of laterality using exergames did not improve speed Of motor processing of lateral arm movements in the same way as physical education traditional
Ryan M. Hulteen et al, Hong Kong 2016	Children's movement skills when playing active video games	Perceptual and Motor Skills, Vol 121(3), Dec, 2015. pp. 767-790.	APA PsycInfo movement skills, active video games, children	n = 19 age = 6-10	avg role in improving real-life movement skills.	Skill components were performed more correctly

			play			during skill assessment than during playback via AVG.

Table 2 (Source: author's own study)

2. Discussion

The prevalence of obesity and overweight is rising steadily and is currently considered a global epidemic. In particular, obesity is increasing at particularly alarming rates among children, affecting short- and long-term health (Paw et al., 2008). The World Health Organization lists obesity as a major public health problem affecting all age groups (Braga et al., 2017). The potential health and social consequences of childhood obesity include heart disease, type 2 diabetes, sleep apnea, hypertension, premature death, alienation from peers, and depression (Fogel et al., 2010). In addition, childhood physical activity can form the behavioral patterns necessary for health benefits later in life (Rhodes et al., 2018). It is recommended that children aged 5 to 12 years accumulate at least 60 minutes per day of physical activity of moderate to high intensity. However, worldwide, many children do not meet these Guidelines (Johnson et al., 2015). Some research suggests that only 42 percent of children meet the recommended daily amount of physical activity (Reynolds et al., 2018). In today's society, they spend more and more time in sedentary behaviors: the increasing prevalence of technology, such as computers, the Internet, and video games, has been considered a major cause of sedentary lifestyles in young people, which in turn results in the increase of overweight and obesity (Sun, 2013).

Scholars have explored the use of video games that require active interaction with the game interface, or exergames, as a way to combat the growing sedentary lifestyle (Ho et al., 2017). Exergaming seems to have the potential to promote a physically active lifestyle (Gao & Xiang, 2014). Active video games (AVGs) that

require whole-body movement to play may be an innovative health promotion tool to replace sedentary pastimes (De Vet, Simons &Wesselman, 2014). AVGs have been suggested as a strategy for overweight/obese and/or sedentary children to increase their light and moderate physical activity (Hulteen et al., 2015).

Selected studies have focused their attention on different aspects of active video game use. Some researchers, for example, delved into the issue of motivation and perception. Reducing inactivity by replacing non-active play with active play will only be feasible and effective if children have positive views toward AVGs (De Vet, Simons & Wesselman, 2014). Sun (2013) showed that exergaming exerts strong, attractive characteristics that can induce a high level of motivation. Lee, Xiang, and Gao (2017) argue that AVGs can reduce negative moods such as anger and depression. Exergames can serve as a healthy outlet for emotional relief and mood enhancement to help children cope with various stresses (Ho et al., 2017). Choice is another potentially important factor. Choice promotes the experience of autonomy, which in turn improves intrinsic motivation (Roemmich et al., 2012). Although these studies show that exergames succeed in motivating children to actively participate in physical activity, concerns remain about the value of video games in terms of acquiring motor skills and competencies. There are differing opinions regarding the comparison between traditional physical activity and the use of exergames. Research conducted in 2017 (Braga et al.) showed no significant differences between the motivation level and physical activity level of children in traditional physical education classes and children in physical education classes with the use of virtual games; in contrast, another study (Fogel et al., 2010) showed how the use of AVGs can improve physical activity level in children commonly considered inactive.

It has been suggested that exergames should be incorporated into physical education courses to improve student motivation, increase physical activity, and facilitate the learning of motor skills (Sun, 2013). As participation in physical activity

in young people decreases with age, promoting daily participation in physical activity in school-age children has become an important public health initiative (Gao & Xiang, 2014). The acquisition of fundamental motor skills is a characteristic of this developmental stage; it becomes an important element both for the development of specific motor behaviors, but also and especially for enhancing and promoting different aspects of growth from a cognitive, social, and cultural perspective (Sgrò, Barresi & Lipoma, 2016). Movement skills can be considered the building blocks of successful participation in physical and sport-specific activities (Rosa, Ridgers & Barnett, 2013). Fundamental motor skills (FMS) have been seen as the "building blocks" for lifelong physical activities (Vernadakis et al., 2015). Yet, few children achieve basic FMS competence (Johnson et al., 2015). Without these "building blocks," they are at risk of being physically inactive and less fit in their adult lives. Some studies investigate this very possibility of active video gaming to improve the acquisition of basic movement skills in children, particularly object control skills. In 2016, research pointed out that the Nintendo Wii™, which requires the use of a handheld controller, could instead even reduce the range of motion (e.g., moving only the wrist to swing a tennis racket) for the controller to perform the game action (Hulteen et al., 2015). The usefulness of Xbox Kinect for developing perceived and actual object control skills is also questionable (Johnson et al., 2015). The current findings may therefore suggest that the use of these virtual tools may not be ideal for teaching motor skills in physical education (Rosa et al., 2013). A 2015 study reached different results (Vernadakis et al., 2015): the use of the Xbox Kinect game console is a valuable, feasible, and enjoyable approach to improving children's object control skills. Sgrò, Barresi, and Lipoma (2016) also state that the exergames-mediated motor activity protocol contributes favorably to the proficiency levels of the solicited skills. Studies related to the analysis of the use of dance-based exergames are interesting. Research in 2008 (Paw et al.) was among the first to analyze children's level of motivation in an interactive dance video game.

Dance and rhythmic activities can elicit higher rates of MVPA than traditional activities. Most of the research on dance-related exergaming has been conducted on *Dance Dance Revolution* (DDR). Some of the studies conducted in this field have shown a very high level of interest in interactive dance games compared to tag games (Gao, Zhang & Podlog, 2013; Gao & Xiang, 2014); contextually, other research shows that participation and motivation increase with the use of DDR, but the difference between total steps taken in-game and out-of-game (children mirror the actions but do not receive direct feedback) is not statistically significant **(**Reynolds et al., 2018).

3. Limits and Future Prospects

The research highlights some limitations. For example, small sample size; technical problems; questionnaires not exhaustive; instrumentation not adequately objective; a limited variety of exergames, limited; time not adequate for the development of the phenomenon to be observed. Future research could bring out new questions and scenarios (e.g., the mechanisms of gender difference relative to perceptions of AGVs), broaden the audience by involving more children and/or families of different ethnic backgrounds, or contemplate a broader typology of AVGs (not only Nintendo Wii or Xbox Kinect).

Conclusions

The overall evidence that emerges is that exergaming is a valuable vehicle for promoting physical activity participation and fitness among young people. Exergaming-based exercise benefits children physically and emotionally (Gao & Xiang, 2014). Technology provides a valuable "gateway" that paves the way toward children's increased participation and engagement in motor activity. This is also because of the new generations' high level of knowledge and confidence in using electronic games and the virtual world. Studies have shown that enjoyment

(attractiveness) is a strong intrinsic factor of AVGs. However, this is not sufficient to demonstrate equivalence between exergaming and traditional physical activity, not only in terms of skill and competence acquisition but also in terms of metabolic and energy expenditure. Indeed, analyses have highlighted how calories expended during exergaming may not exceed those burned during traditional game activities (Gao, Chen & Stodden, 2015; Roemmich et al., 2012). Consequently, in the current state of research, it can be argued that active video games certainly contribute to the fight against childhood obesity but are not decisive or entirely decisive. For this reason, some speculate that digital technology should not be included in the school curriculum (Rosa, Ridgers, & Barnett, 2013). Others, however, are inclined to believe that exergaming can be integrated into schools as an excellent addition to promoting physical activity (Gao, Chen, & Stodden, 2015). There is still not much empirical evidence about the validity of using AVGs in the context of motor learning. The results are not unanimous: the discord is not so much pertinent to motivation (certainly greater with participation in active games) as it is to whether AVGs provide the same motor skills and competencies that traditional physical education allows people to gain. Active video games were born and designed for fun and play. While their attractiveness facilitates engagement in physical activity and sports in the way they are designed, they cannot be considered a substitute for traditional physical activity or non-active play. Undoubtedly, they represent a technology of interest to the educational world, as they are instrumental in the development of fundamental motor skills (Sgrò, Barresi & Lipoma, 2016). In summary, exergaming cannot be considered on par with traditional physical activity (skill, energy expenditure); however, it presents itself as a viable hypothesis for an educational strategy, not in terms of replacing traditional physical activity but rather in terms of supporting and supplementing it. Active video game labs, also open during out-of-school hours, could be hypothesized; mixed programs of motor activity (traditional tag games) and active digital games could be devised;

homework could be given on interconnected platforms. The potential is enormous and yet to be explored.

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