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Research in Serious Games for People with Intellectual Disability: a Meta-analysis Study

C Sousa, J C Neves, M J Damásio

CICANT, Lusófona University,
Lisbon, PORTUGAL

carla.patricia.sousa@ulusofona.pt, josecsn@ulusofona.pt, mjdamasio@ulusofona.pt

<https://cicant.ulusofona.pt/>

ABSTRACT

Currently, the potential of games as an intervention tool in a broad range of areas has been increasingly explored by researchers. Notwithstanding, and when considering individuals with Intellectual Disability (ID), the need for more data emerges, as well as the need to systematize and summarize such data, allowing evidence-based decisions to all the stakeholders in this field. The present study aimed to systematize the existing evidence regarding the effectiveness of serious games in the promotion of life skills in people with ID. Several scientific databases were consulted, as well as researchers' social networks to obtain a sample as wide as possible. Through a process composed by different phases, several inclusion and exclusion criteria were applied to the initial search results. The obtained sample of studies ($N = 8$) was then systematically analyzed, including a meta-analysis procedure, to summarize the quantitative data on the effectiveness of serious game based interventions for people with ID. Results from the meta-analysis study emphasize larger effect-sizes than conventional methods (non game-based) interventions with people with ID (fixed-effects, $g = 0.417$; 95% CI [0.169, 0.666]; $Z = 3.293$, $SE = 0.127$, $p = .001$), in the promotion of a broad range of variables associated with well-being, from cognitive abilities to psychotherapy related skills. Such results can frame the discussion regarding serious games as a relevant and feasible strategy to promote skills in people with ID, allowing evidence-based decisions in this field, aimed at supporting an increasing and enhanced inclusion of games in their daily lives.

Keywords: Intellectual Disability; Serious Games; Systematic Literature Review; Meta-analysis.

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1. INTRODUCTION

Intellectual Disability (ID) is defined as a disorder with onset during the developmental period that includes both intellectual and adaptive functioning deficits in conceptual, social and practical domains (APA, 2013). The social paradigms of approaching ID have been gradually changing, from social charity to social citizenship, through the inclusion - segregation - integration - inclusion path (Emygdio da Silva, 2009; Fontes, 2009). These changes are in line with the centrality currently attributed to the context in defining the effective disability of people with ID. According to the World Health Organization (WHO), although ID is seen as an health condition, from which results a set of impairments in body functions and structures, activity limitations, and participation restrictions, all these factors can only be understood when considering their complex interactions with the contextual factors, that comprise both personal factors and environmental barriers and hindrances (WHO, 2001). In the field of intervention, practices mainly based on medical/biological perspectives have been gradually replaced by more holistic perspectives (Emygdio da Silva and Coelho, 2009).

Currently, the potential of games as intervention strategies in the fields of learning (Sousa and Costa, 2018), cognition (Pallavicini et al., 2018; Rosa et al., 2016), and motivation (Granic et al., 2014) has been increasingly supported by research. Particularly, in the field of ID, games have been considered as a relevant alternative to the current therapy/training methods, though the recognized need for developing new and innovative games that can

truly correspond to subjects' needs (Tomé et al., 2014). Moreover, games are also being discussed as having a potential to foster the decrease of the environmental barriers and hindrances that people with ID face in their specific contexts (Sousa, 2020).

Games for ID, as a specific field in game studies has been primarily focusing on three types of main aims: learning or skills promotion; the definition of methodologies for game design and game development; and the identification of patterns and behaviours in the use of video games by people with ID (Cano et al., 2015). The need for more empirical results and the methodological weaknesses of the existing studies in the field has also been highlighted (Cano et al., 2015; Jiménez et al., 2015).

In the broad field of social sciences, the increasing rate of studies being conducted, as well as the need to synthesize both the differences and similarities across studies, their methodologies and results, place the need to organize and summarize the existing research as a priority, compared with the need to develop completely new research. One of the possible methods to effectuate such progression in an area of knowledge is through the conduction of meta-analysis, a methodological and statistical approach to drawing conclusions from empirical literature (Card, 2012).

Besides research, also in the field practice, the selection of interventions and treatments must be considered the most critical activity of practitioners committed to improving the outcomes and lives of individuals with ID. Therefore, it is crucially important for them to know the most effective interventions or evidence-based programs for such population. Moreover, evidence-based practices in the field of ID are considered as relevant for all the involved stakeholders, but more directly for teachers, administrators, service providers, and support teams. Aligned with this, the need to widespread the application of such practices for individuals with ID is currently considered a high priority for improving the outcomes with this population (Stoiber et al., 2016).

The present study aims to summarize the most recent evidence on the effectiveness of serious games in the promotion of a broad range of life skills in people with ID, through a meta-analysis study. Ultimately, it is expected that the obtained results allow evidence-based decisions in this field, aimed at supporting an increasing and enhanced inclusion of serious games in the intervention practices with this population.

2. METHOD

2.1 Sample Selection Process

Studies primarily focusing on people with intellectual disability were included in the sample. The use of a specific “gold standard” diagnosis for participants to be classified as ID was not considered as an inclusion criterion. Studies were included regardless of participants' type or degree of ID. Studies primarily focusing on people with dementia and Alzheimer's disease were excluded, as well as studies approaching other disabilities, like learning disabilities, such as Attention Deficit Hyperactivity Disorder (ADHD), that are frequently confused in literature.

Studies were included if there was a control group for comparison, and if they make usage of serious games as a strategy to promote any type of life skill, compared with conventional intervention methods. Regarding the research design, to be included studies must constitute experimental approaches and, most specifically, Randomized Controlled Trials (RCTs). A broad definition of serious games was adopted, considering the premise that “not all game characteristics, such as, challenge, fun and play are appropriate descriptions or labels for all serious games” (Marsh, 2011). Thus, studies making usage of games, simulations, or experimental/experiential environments with a purpose (Marsh, 2011) were included in the sample.

Since this meta-analysis is part of a broader Systematic Literature Review study, the schematic search process did not start by searching only for RCTs, with this inclusion criteria being applied in the end of the eligibility phase. The process started with a schematic scientific database search, including Ebsco, PubMed, B-On (the largest database in Portugal, with most of the other ones associated with it), Academia.edu, and ResearchGate, by using the following terms and Boolean operators: [games AND (intellectual disability)]. Variations of this search formula included different forms of designating ID, such as “cognitive disability”, “intellectual disabilities”, other expressions such as “serious games” among others. Academia.edu and ResearchGate were also used as a data collection tool, to access Grey Literature, explicitly eventual research outcomes not controlled by commercial publishers. This process constitutes the Identification phase of the SLR.

The following phases were based in a set of inclusion criteria set out above, regarding ID and serious games. To be included, studies must also be published in sources that include a peer-review process, and clearly approach the use of games for the promotion of life skills in people with ID. Additionally, and considering the study aim of systematizing the most recent scientific evidence, the included studies were published between January 2010 and February 2020 (the systematic search was developed in early March 2020).

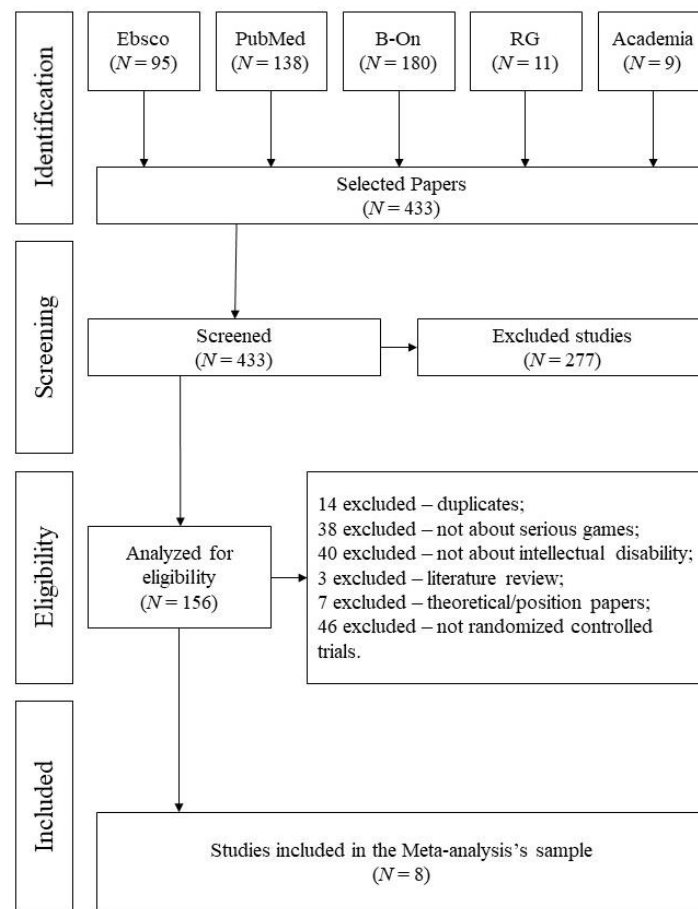


Figure 1. Flowchart of the sample selection process.

Using the above defined criteria, 8 scientific papers were included in the final sample. The selection process throughout this sample is represented in Figure 1. In the Screening phase, the criteria were applied at a superficial level, meaning that only titles, abstracts and general information were considered. In the Eligibility phase the criteria was followed by thoroughly analysing each study, before deciding on including or excluding it. The final sample is composed by: Study 1 (Choi et al., 2012); Study 2 (Söderqvist et al., 2012); Study 3 (Tsimaras et al., 2014); Study 4 (Brankaer et al., 2015); Study 5 (Siberski et al., 2015); Study 6 (García-Villamisar et al., 2017); Study 7 (Cooney et al., 2017); and Study 8 (Silva et al., 2017).

2.2 Data Analysis

The selected papers were analysed considering two different matrices. First, some general aspects of the research were categorized, namely year of publication, sample size (N), sample age group, aspects regarding ID, research aims, expected intervention's outcomes, and aspects regarding serious games and platform. The gathered data was then analysed using the Statistical Package for the Social Sciences (IBM SPSS), version 22. Next, studies were analysed considering the reported quantitative results, which were summarized using the Comprehensive Meta-Analysis Software (CMA), version 2.

In the meta-analysis, hedges' g was adopted since it provides a superior estimate of the standardized mean difference in small samples (Higgins et al., 2003). Considering the nature of the meta-analysis results and

nonstatistical assumptions regarding studies similarity, a fixed-effects model was also adopted (Tufanaru et al., 2015).

3. RESULTS

3.1 Overview of Studies

Eight studies matched the inclusion criteria. The present meta-analysis as a total sample of 301 subjects with ID, with an average of 37.63 individuals per included study. Samples in the studies ranged between 20 and 62 subjects.

Regarding the year of publication, it is possible to observe that all studies are from the last 10 years. Therefore, it can be safeguarded that the reported data corresponds to the most recent scientific evidence. The distribution by years was as follows: 2012 – two studies (25.0%), 2014 – one study (12.5%), 2015 – two studies (25.0%), 2017 – three studies (37.5%).

Five studies in this meta-analysis (62.5%) had a sample composed by adults, while three studies (37.5%) were mainly focused on children and/or youth. The samples were mainly composed by individuals with ID. In some cases, researchers indicated further specifications about the diagnosis, particularly concerning the level of impairment (e.g. mild ID) or the existence of comorbidities (e.g. ASD, anxiety, or depression). It is relevant to note that all the studies ($N = 5$; 62.5%) specifying further conditions regarding ID and the level of impairment had included individuals with mild or mild to moderate ID in the sample (Brankaer et al., 2015; Choi et al., 2012; Cooney et al., 2017; Silva et al., 2017; Tsimaras et al., 2014). Further information on sample composition and characterization of the studies in this sample is detailed on Table 1.

Table 1. *Characterization and composition of the studies in the sample ($N = 8$).*

Study ID	Sample Size	Sample characterization
Study 1	$N = 29$	“Students under the age of 18, with mild intellectual disability and attending primary one to three were recruited.” (Choi et al., 2012)
Study 2	$N = 41$	“All participants had ID ($IQ < 70$, retrieved from clinical records) and were registered with the mental habilitation center in the area of Buskerud in Norway.” (Söderqvist et al., 2012)
Study 3	$N = 20$	“This study involved 20 adults aged 20-25 years (...), and with moderate ID ($IQ: 35-50$) (...)” (Tsimaras et al., 2014)
Study 4	$N = 30$	“Participants were 30 children with mild ID (...)” (Brankaer et al., 2015)
Study 5	$N = 32$	Adults with ID (Siberski et al., 2015).
Study 6	$N = 40$	“(...) adults with ASD and ID who met DSM-IV criteria (...)” (García-Villamizar et al., 2017)
Study 7	$N = 52$	“Fifty-two adults with mild to moderate ID and anxiety or depression (...)” (Cooney et al., 2017)
Study 8	$N = 27$	“Twenty-seven adults with Down Syndrome (DS) (...)” (Silva et al., 2017)

Considering the main aim of the studies in this sample we can broadly state that they intended to explore the promotion of life skills in people with ID through interventions based on serious games. We can consider as life skills, a broad range of variables, that can be directly or indirectly associated with well-being, from cognitive abilities to psychotherapy-related skills. Most specifically, the studies aimed to the promotion of: skills associated with the so-called Daily Life Activities (Choi et al., 2012); cognitive abilities (García-Villamizar et al., 2017; Siberski et al., 2015; Söderqvist et al., 2012); behavioural aspects, associated with other clinical symptomatology (Cooney et al., 2017; Tsimaras et al., 2014); learning associated outcomes (Brankaer et al., 2015); and physical/motor outcomes (Silva et al., 2017). It is relevant to clarify the expected outcomes above categorized are not mutually exclusive, and it is possible to hypothesize that improvements on cognitive abilities can ease individuals’ performance on daily life activities or learning tasks, for example. Nevertheless, since the studies did

not present data regarding skills transferability, these categories were developed based on the aims systematized on Table 2.

Table 2. Main aims of the studies in the sample ($N = 8$).

Study ID	Aim
Study 1	<i>"To motivate children ID to learn handwashing and improve their performance by using computer-assisted teaching method."</i> (Choi et al., 2012)
Study 2	<i>"(...) we investigated the feasibility of cognitive training for improving Working Memory (WM) and Non-Verbal Reasoning (NVR)."</i> (Söderqvist et al., 2012)
Study 3	<i>"The purpose of this study was to examine the effect of a digital interactive game in distractibility, hyperactivity, impulsiveness and other relative symptoms in individuals with Attention Deficit Hyperactivity-Disorder (ADHD) and ID."</i> (Tsimaras et al., 2014)
Study 4	<i>"(...) we developed and evaluated a numerical domino game that specifically targeted the association between these digits and the numerical magnitudes they represent."</i> (Brankaer et al., 2015)
Study 5	<i>"To investigate whether participants with ID would improve in cognitive function after cognitive training (...) "</i> (Siberski et al., 2015)
Study 6	<i>"(...) to examine effects of a therapeutic recreation program designed to increase Executive Function (EF), social skills, adaptive behaviours and well-being of adults with Autism Spectrum Disorder (ASD) and ID."</i> (García-Villamizar et al., 2017)
Study 7	<i>"To evaluate the utility of a Cognitive-Behavioural Therapy (CBT) computer game for adults who have an intellectual disability."</i> (Cooney et al., 2017)
Study 8	<i>"This study aims to analyse the effects of a Wii-based exercise program on physical fitness, functional mobility and motor proficiency of adults with DS."</i> (Silva et al., 2017)

Several games were used in the studies, from the ones specifically aimed at cognitive training aimed to commercial games, which can be justified by the broad concept of serious games adopted in this meta-analysis. Choi et al (2012) used a simulation game based, where the interaction was based on a tangible hand washing station (with faucet, soap dispenser, and towel). Both Siberski et al. (2015) and Söderqvist et al. (2012) used serious games based on already existing cognitive training applications and/or computerizes tasks for the intervention. Tsimaras et al. (2014) intervention was based on a digital interactive tennis game, and Silva et al. (2017) also adopted sports-related motion-based games, in this case commercial ones. García-Villamizar et al. (2017) included "instructional electronically based games" in their therapeutic recreation intervention strategy. Cooney et al. (2017) adapted a previously developed CBT game and mobile application for children to the needs of adults with ID, suffering from anxiety and/or depression. Brankaer et al. (2015) is the only study in the sample using an analogical serious game, in this case a numerical domino game. Regarding the games' platforms, most were computer games ($N = 5$; 62.5%); followed by motion-based games, for Nintendo Wii or another non-specified platform ($N = 2$; 25.0%); and one analogical game (12.5%).

3.2 Meta-analysis

In Study 1, results showed that children with ID can improve their handwashing skills, using a tangible simulation game (Choi et al., 2012) ($g = 0.087$; $CI = 95\%$; $-0.657 - 0.832$). Study 2 supported children's improvements in WM and NVR through their inclusion in an intensive and computerized adaptive cognitive training process (Söderqvist et al., 2012) ($g = 0.017$; $CI = 95\%$; $-0.585 - 0.619$). In study 3, a digital interactive game was effective to improve distractibility, hyperactivity and impulsivity in adults with both ID and ADHD (Tsimaras et al., 2014) ($g = 2.333$; $CI = 95\%$; $1.225 - 3.441$). Study 4 makes usage of an analogical numerical domino game to effectively increase children's learning outcomes regarding numbers and the numerical magnitudes they represent (Brankaer et al., 2015) ($g = 0.358$; $CI = 95\%$; $1.225 - 3.441$). In Study 5, adaptive computerized cognitive training was used to effectively improve cognitive training in adults with ID (Siberski et al., 2015) ($g = 0.248$; $CI = 95\%$; $-0.577 - 1.074$). Study 6 reports EF gains in adults with ID, through their enrolment in leisure activities that include electronically based games (García-Villamizar et al., 2017) ($g = 0.736$; $CI = 95\%$; $0.108 - 1.365$). In Study 7, a CBT computer game was used to to produce clinically significant change in anxiety symptoms in adults with ID (Cooney et al., 2017) ($g = 0.506$; $CI = 95\%$; $-0.065 - 1.078$). Study 8 supports Wii based exercises as an effective

tool to improve physical fitness, functional mobility and motor proficiency in adults with ID, most specifically DS (Silva et al., 2017) ($g = 0.088$; $CI = 95\%$; $-0.671 - 0.847$).

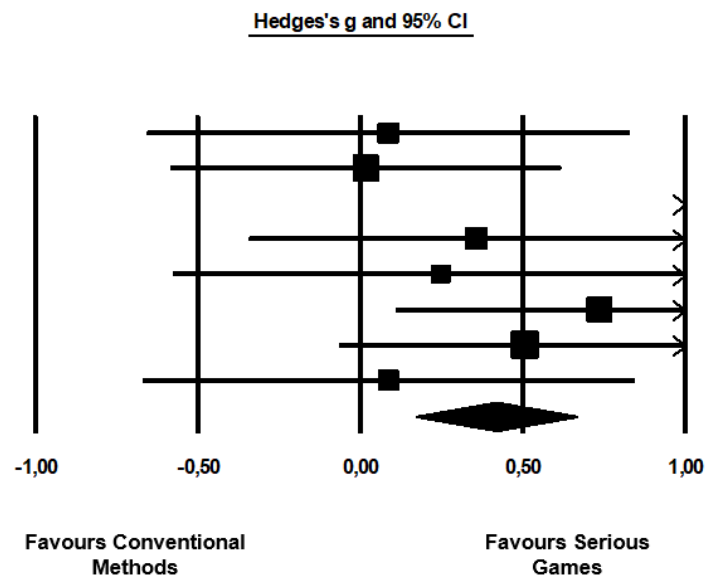


Figure 2. Forest plot for effect sizes (Hedge's g) and 95% confidence intervals from individual studies.

Using a fixed-effect analysis, the effect ratio for the eight studies was 0.417 with a confidence interval of 0.169 to 0.666, which indicates that interventions based on serious games can increase the interventions' outcomes by at least 15%, and per chance by as much as 65% in comparison with conventional methods ($Z = 3.293$, $SE = 0.127$, $p < .005$). Results are shown in Figure 2.

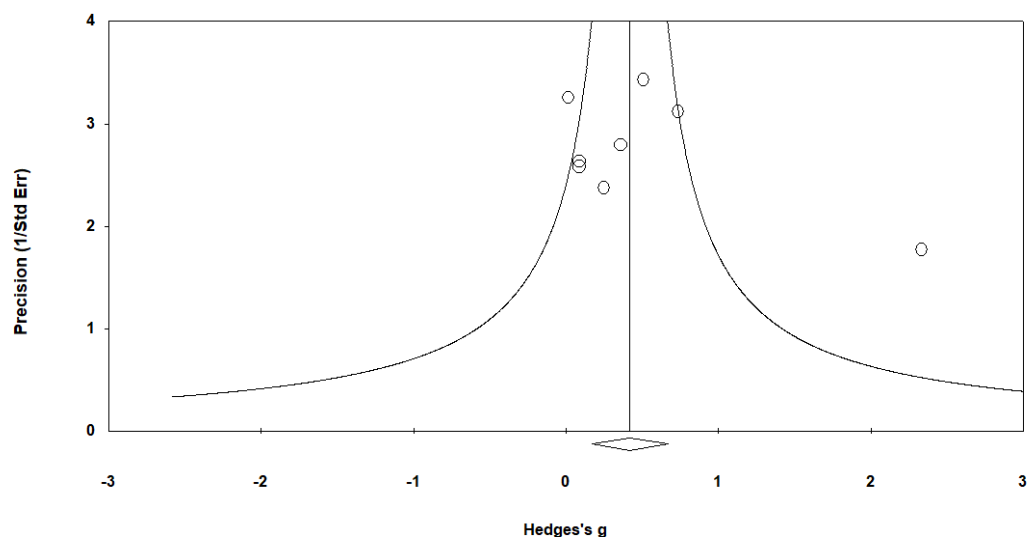


Figure 3. Funnel plot of precision (Hedge's g).

The studies have demonstrated an absence of reporting bias since the funnel plot was symmetrical, as shown in Figure 3. The heterogeneity between studies in the analysis is significant and moderate ($I^2 = 56.069$; $p < .05$).

4. CONCLUSIONS

The present study analysed a sample of eight studies, from an initial search including more than 400 studies, aiming to summarize the most recent evidence on the effectiveness of serious games in the promotion of a broad range of life skills in people with ID. In the sample's summarized results, the approaches based on serious games seems to

show consistent gains in the promotion of several different skills in individuals with ID. The meta-analysis results point towards the existence of statistically significant differences between groups, being the interventions including serious games more effective than other conventional intervention methods.

Considering these data, using serious games can be considered a valid approach in the process of promoting skills in individuals with ID, supported by enough scientific evidence to frame its wider adoption as an intervention methodology. The obtained data regarding the effect-sizes of such interventions allow evidence-based decisions in this field, aimed at supporting an increasing and enhanced inclusion of games in the daily lives of people with ID. In addition, the collected sample shows that significant differences are found with both children and adults, and in the promotion of different types of skills, including the ones related with daily life activities, cognitive abilities, psychotherapy outcomes, motor outcomes, or learning-related abilities. This data strengthens the transversal potential of serious games in biopsychosocial approaches with individuals with ID, considering their ability to promote several skills within one type of intervention. This data also reinforces the prominent future of serious games as valuable intervention tools, with populations where the therapeutic answers are often seen as limited.

Some limitations of this study may include some heterogeneity of the research designs and the requirement for RCT as a factor of exclusion of a significant part of the sample studies, ending with a sample size not as larger as initially hypothesized. Also, RCTs frequently assess pre and post skills in the samples' individuals, without assessing their progress in the intervention, including motivational aspects, or other more subjective constructs, that can also be very relevant.

Future research must include the studies that are being carried out, separating the analysis of effectiveness by more specific aspects, for example regarding the serious games, age groups, or the context where the study was developed. Moreover, aspects related with specific game designs, gameplay environments, and game mechanics should be analysed, regarding its effectiveness in the intervention, and discriminating the most suitable for the promotion of each group of skills. Considering the lack of experimental approaches with RCTs in this field, that conditioned the sample size of this study, future studies should also consider the need to adopt research designs as systematic as possible and to report the obtained data in detail. Other relevant aspect regarding serious games and ID that would be relevant in futures studies is the exploration of the transferability of the obtained outcomes to subjects' daily lives, and to activities outside the scope of the study.

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