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ARTICLE

Does exergaming promote well-being in adults?

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Abstract

Background: Physical inactivity is a pervasive issue despite the well-known health benefits of habitual exercise. Novel interventions – such as exergaming – represent a viable option to address the physical inactivity crisis yet little is known about the effects on well-being attributable to exergaming in adults. ***Purpose:*** The purpose of this review was to synthesize the current status of published research using exergaming as a platform to change well-being in adults. ***Methods:*** Following a comprehensive search of electronic databases (N = 5), a multi-phase filtering process resulted in 24 studies that were coded for this review. All retained studies were (a) published in English, (b) used exergaming as an intervention, and (c) measured at least one marker of well-being that served as a dependent variable. ***Results:*** Mixed support was evident for improved well-being as a function of exergaming in adults. Less than 50.0 percent of the coded studies using either multi- or single-group (pre-posttest) research designs reported enhanced well-being as a function of exergaming. Heterogeneity in research designs, variety in measuring well-being, plus an overreliance on null-hypothesis significance testing were evident in studies focused on the contributions of exergaming to well-being. ***Conclusions:*** Overall, it seems that exergaming has potential for improving well-being in adults. However, the evidence-base supporting widespread use of exergaming as a modality for improved well-being in adults remains equivocal at this juncture. **Health & Fitness Journal of Canada 2018;11(2):3-14.**

Keywords: Physical Activity, e-Technology, Mobile Interventions, Mental Health, Gaming, Quality of Life.

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Introduction

Evidence supports the importance of regular physical activity for reducing all-cause mortality risk (e.g., Ekelund et al., 2016; Warburton et al. 2006), improving quality of life (Conn et al., 2009), and supporting healthy ageing (Daskalopoulou et al., 2017). It is also well-documented that participation in physical activity is sub-optimal in most countries leading many public health experts to label inactivity (and sedentary living) as a global pandemic (Andersen et al., 2016). Public health advocates have responded to these vexing participation rates with calls for novel ways to promote and sustain physical activity (e.g., Heath et al., 2012). One approach that may hold some appeal for changing physical activity behaviour is exergaming (Witherspoon, 2013).

Exergaming uses e-technology as a platform to encourage physical activity (or movement) while immersed in virtual environments (Witherspoon, 2013). Initially developed to counteract the negative effects of excessive screen time behaviour in children/youth (Witherspoon, 2013), subsequent applications of exergaming have proven useful for various clinical (e.g., da Silva Alves et al., 2017) and non-clinical (e.g., Sween et al., 2014) groups across the lifespan. Data from randomized controlled trials (RCT) supports the utility of exergaming as a physical activity intervention to reduce blood pressure (e.g., Huang et al., 2017), increase bone mineral density and reduce total adiposity (e.g., Staiano et al., 2016), improve mobility skills and reduce fear of falling (e.g., Collado-Mateo et al., 2017), optimize postural control (e.g., Barry et al., 2016), and to a lesser degree, enhance cognitive functioning (e.g., Stanmore et al., 2017).

Previous studies have supported the utility of exergaming for improving physical activity behavior and bolstering various health parameters (e.g., reduced blood pressure; Huang et al., 2017), yet less is known about the effects of this approach on well-being. One previous review implies that exergaming – representing a subset of videogaming platforms – holds broad appeal for enhancing well-being since enjoyment and engagement are parameters that can be embedded within videogame design (Jones et al., 2014). Empirical studies (e.g., Mack et al., 2012) and narrative reviews (e.g., Wiese et al., 2017) have substantiated the important role played by leisure-time physical activity as a route to improve well-being; however, these investigations have not addressed the viability of exergaming as an intervention approach. To address this gap, the purpose of this review was to synthesize the research evidence evaluating the utility of exergaming as an intervention modality to change well-being in adults.

Methods

Search Strategy

A comprehensive literature search by two researchers (ESS and DEM) of the following electronic databases was conducted to identify potential studies to include in this review: PubMed, CINAHL, PsycINFO, Cochrane, and Web of Science. Keywords used in the search strategy were as follows: Exergame OR exergam* OR exer-gam* OR exergaming OR active video game OR videogam* OR video-gam* OR video-based OR computer-based OR Wii OR Nintendo OR X-box NOT protein OR Kinect OR play-station OR playstation OR virtua* realit* OR dance dance revolution AND wellbeing AND quality of life AND affect AND vitality AND adults. The keyword phrase "NOT Xbox protein" was included as the Xbox console and the X-box binding protein have similar names that contaminated the results of this search strategy.

Inclusion/Exclusion Criteria

A series of inclusion (and exclusion) criteria were developed *a priori* for this review. The inclusion criteria guiding study selection were as follows: (1) Sample of adults (i.e., ≥ 18 years of age) living without any documented health conditions that may limit or contradict physical activity, (2) Use of exergaming as the only intervention modality, (3) Well-being identified as a study outcome, (4) Published in English, and (5) Use of quantitative data. Further restrictions in terms of study design (e.g., only RCT's, comparators, use of pre-posttest designs, etc.) were not inclusion criteria guiding study selection for this review. Exclusion criteria guiding study selection were as follows: (1) Use of qualitative data, (b) Published in a language other than English, and/or (c) Samples comprised of children/youth (defined as ≤ 17 years of age). Published studies including any/all of the aforementioned exclusion criteria were omitted from subsequent consideration in this review.

Study Selection Process

Each published study identified via the search strategy was imported into EndNote X8 (Clarivate Analytics©, Toronto, Ontario, Canada) and subsequently uploaded to DistillerSR (Evidence Partners, Ottawa, Ontario, Canada) for additional scrutiny. Using the study inclusion/exclusion criteria as a guide, a three-level screening process was defined within DistillerSR using a solitary question per level. *Level 1* screening focused on the publication title using this question: "Is this publication relevant for our study?". *Level 2* infused the screening process with information from the study abstract using this question: "Should this publication go on to full-text screening?". *Level 3* inspected the contents of the abstract plus the full-text for every published study retained from Level 1 and Level 2 screening in DistillerSR using this final question: "Is this publication relevant for this study?". A forced-choice response format (i.e., 'Yes', 'No', 'Cannot tell') was used at each level of screening. Two authors (ESS and DEM) evaluated all published studies at each level of the screening process. Conflicts between coding for study selection were discussed between coders and the third author (PMW) until full consensus was reached.

Data Extraction

Data were extracted from each study retained for this review using a standard form that was developed specifically for this study using recommended best practices for systematic reviews (e.g., Cooper, 1982) combined with previous research (e.g., Mack, Wilson, and Gunnell, 2016). Using this standard form, two authors (ESS and DEM) identified then recorded all relevant data published in each study retained following the study selection process. A copy of the standard form used for coding is available upon request from the first authors (ESS or PMW).

Results

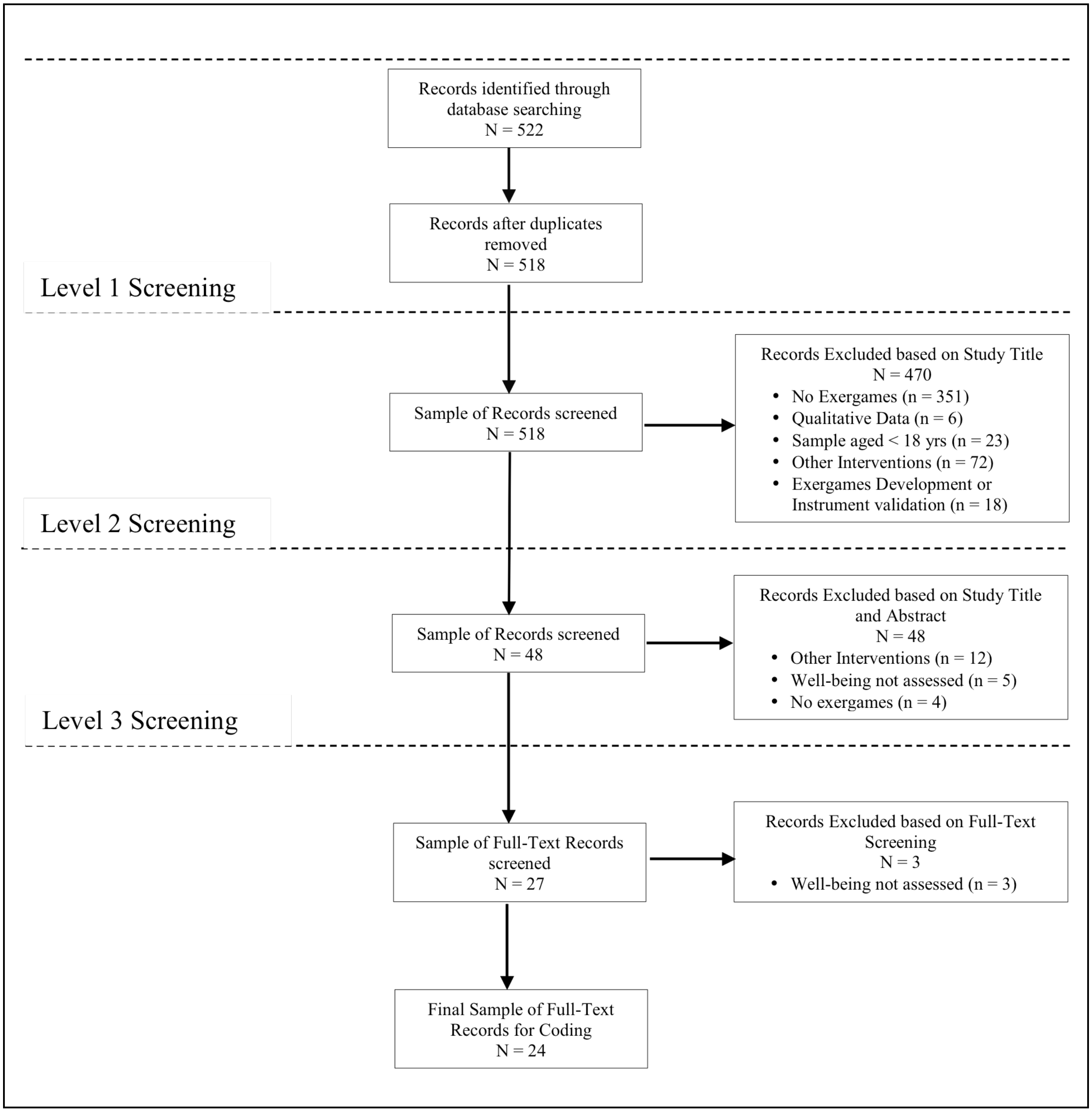
A total of 24 studies met the eligibility criteria for inclusion in this review and were retained following the multi-level screening process (see Figure 1 for details). Table 1 presents a synopsis of the individual studies coded in this review.

***Study Characteristics*:** Nine countries were represented across the coded studies with 45.8 percent originating from the United States of America (see Table 1). Randomized experimental designs (n = 13; 54.2%) were the most frequent approach to study design. One coded study did not specify the research design used for the investigation. Sample sizes varied across coded studies ranging from 5 to 335 participants (M = 50.5 ± 75.6; *Median* = 26.5). Only two studies used samples exceeding 100 participants in total.

***Sample Characteristics*:** Age of participants varied from 20.5 to 83.0 yr (M = 54.9 ± 20.4 yr) with 62.5 percent of the coded studies using samples aged 50.0 yr or older. Over half (54.2%) of the coded studies (n = 13) reported data provided by a sample living with at least one medical condition. Neurological disease was the most common medical condition reported across coded studies (n = 7; 53.9%).

Intervention Characteristics: Table 2 displays characteristics of the exergaming intervention across coded studies. Nintendo Wii/WiiFit (n = 18; 75.0%) was the most popular mode of exergaming

Figure 1: Flow diagram showcasing decision-making at each screening level of the study selection process.



reported followed by Xbox 360 (*n* = 4; 16.7%). A total of eleven (45.8%) coded studies reported details concerning the intensity used as the intervention stimulus when exergaming. 'Progressive' (*n* = 6; 54.5%) was the most common metric defining exergaming intensity reported in coded studies followed by 'moderate' (*n* = 3; 27.3%) then 'self-selected' (*n* = 2; 18.2%). Eighteen studies (75.0%) reported duration of exergaming as an intervention stimulus in terms of days per week. In this subset (*n* = 18), the modal intervention duration was 3.0 d/wk (*M* = 3.0 ± 1.2 d/wk; *Range* = 1.0 to 5.0 d/wk). Studies lasting more than one week (*n* = 21; 91.7%) varied from 2.0 to 14.0 weeks (*M* = 7.4 ± 3.49 wk) in total duration.

Table 1: Summary of research design and sampling characteristics.

Study Authors	Year	Country	Design	Sample	Sex	N	Age (yr)
Rosenberg et al.	2010	US	SGD	C	M/F	19	78.7
Douris et al.	2012	US	RCOD	H	M/F	21	23.2
Herz et al.	2013	US	SGD	C	M/F	33	66.7
Keogh et al.	2013	AU	QED	H	M/F	34	83.0
Kloos et al.	2013	US	SGD	C	M/F	18	50.7
Rosipal et al.	2013	US	SGD	C	M/F	18	22.1
Tseng and Hsieh	2013	CN	SGD	C	M/F	60	59.3
Chao et al.	2014	US	SGD	H	M/F	7	80.0
Konstantinidis et al.	2014	GR	RED	H	M/F	232	69.5
Maillot et al.	2014	FR	N/S	H	M/F	16	74.0
Naugle et al.	2014	US	QED	H	M/F	22	20.5
Viana et al.	2014	BR	RED	C	M/F	20	55.5
Wall et al.	2015	US	ITSD	C	M	5	58.6
Şimşek et al.	2015	TR	RED	C	M/F	42	57.8
Ribeiro et al.	2015	BR	RED	C	M/F	30	52.9
Karahan et al.	2015	TR	RCOD	H	M/F	90	71.4
Seber et al.	2016	US	SGD	C	M/F	14	52.7
Karahan et al.	2016	TR	RED	C	M/F	57	36.3
Monedero et al.	2016	IE	RCOD	H	M/F	23	24.8
Mackintosh et al.	2016	UK	RCOD	H	M/F	36	22.0
Ribas et al.	2017	BR	RED	C	M/F	20	60.9
Padala et al.	2017	US	RED	H	M/F	30	68.3
Padala et al.	2017	US	RED	C	M/F	30	73.0
Huang et al.	2017	TW	RED	H	M/F	335	N/S

Note. RED = Randomized Experimental Design. RCOD = Randomized Cross-Over Design. QED = Quasi-Experimental Design. ITSD = Interrupted Time-Series Design. SGD = Single-Group Design (pretest-posttest assessments). H = No diagnosed medical conditions specified by study authors. C = Diagnosed medical conditions specified by study authors. M = Male. F = Female. N/S = Not Specified (or unable to determine based on information provided in the study). N = Sample size (this value is the total sample across all conditions within a study reported by the authors). Age = Mean age calculated across any/all groups reported by authors. US = United States of America. AU = Australia. CN = China. GR = Greece. FR = France. BR = Brazil. TR = Turkey. IE = Ireland (Eire). UK = United Kingdom. TW = Taiwan.

Exergaming and Well-Being: Seven studies (29.2%) assessed well-being using the Medical Outcomes Survey-Short Form 36 (Ware and Sherbourne, 1992). Of the remaining studies, five studies (20.8%) used a disease-specific quality of life instrument while four studies (16.7%) used the brief version of the World Health Organization Quality of Life instrument (World Health Organization, 2002). The remaining studies (n = 8; 33.3%) used seven different instruments to assess well-being. Seventeen of the coded studies used a multiple-groups research design with 35.3 percent (n = 6) reporting greater well-being in the exergaming group compared to other treatments (e.g., cognitive training, 'do-as-you-do', etc.; Huang et al., 2017; Karahan et al., 2016; Konstantinidis et al., 2014; Maillot et al.,2010; Monedero et al., 2016; Viana et al., 2014). Over half of the coded studies (62.5%) using multi-group research designs reported no significant between-

Table 2: Summary of intervention characteristics.

Study Authors	Mode	Duration	Frequency	Intensity	Time
Rosenberg et al.	NWii	12 wk	3 d/wk	N/S	35 min/wk
Douris et al.	NWiiFit	2 wk	2 d/wk	Mod.	30 min/d
Herz et al.	NWii	8 wk	3 d/wk	N/S	60 min/d
Keogh et al.	NWii	8 wk	SS	N/S	30±24min/d
Kloos et al.	DDR	6 wk	2 d/wk	Prog.	45 min/d
Rosipal et al.	NWii	2 wk	SS	SS	60 min/wk
Tseng and Hsieh	Hot Plus	2 wk	3 d/wk	N/S	20 min/d
Chao et al.	NWiiFit	8 wk	2 d/wk	N/S	60 min/d
Konstantinidis et al.	NWiiFit	8 wk	5 d/wk	Prog.	N/S
Maillot et al.	NWiiFit	14 wk	24 sessions	Prog.	60 min/d
Naugle et al.	NWii	3 d	2 sessions/d	SS	20 min/session
Viana et al.	NWii	5 wk	3 d/wk	N/S	60 min/d
Wall et al.	NWii	7 wk	2 d/wk	N/S	60 min/d
Şimşek et al.	NWii	10 wk	3 d/wk	N/S	45-60 min/d
Ribeiro et al.	NWii	2 mths	2 d/wk	Prog.	50 min/d
Karahan et al.	Xbox 360	6 wk	5 d/wk	N/S	30 min/d
Seber et al.	NWii	12 wk	3 d/wk	Mod.	60 min/d
Karahan et al.	Xbox 360	8 wk	5 d/wk	N/S	30 min/d
Monedero et al.	Xbox 360	6 d	4 sessions	Mod.	30 min/session
Mackintosh et al.	NWii	N/R	2 sessions	N/S	30 min/session
Ribas et al.	NWii	12 wk	2 d/wk	N/S	30 min/d
Padala et al.	NWii	8 wk	3 d/wk	Prog.	45 min/d
Padala et al.	Nwii	8 wk	5 d/wk	Prog.	30 min/d
Huang et al.	Xbox 360	2 wk	1 d/wk	N/S	30 min/d

Note. N/S = Not reported by study authors (or unable to determine based on information provided in the study). NWii = Nintendo Wii. NWiiFit = Nintendo Wii Fit. Mod. = Moderate Intensity. Prog. = Progressive Intensity. SS = Self-Selected Intensity. Duration is reported in terms of months (mths), weeks (wk) and/or days (d) as noted by the study author(s).

groups differences in well-being (da Silva Ribeiro et al., 2017; Karahan et al., 2015; Keogh et al., 2013; Kloos et al., 2013; Mackintosh et al., 2016; Naugle et al., 2014; Padala et al., 2017; Padala et al., 2017; Ribas et al., 2017; Simşek et al., 2015). One study using a randomized cross-over design reported greater well-being in participants when engaged in brisk walking compared to exergaming (Douris et al., 2012). Seven of the coded studies reported using single-group (pre-posttest) research designs with 42.9 percent (n = 3) reporting improvements in well-being from pre-to-post assessment (Herz et al., 2013; Rosenberg et al., 2010; Seber et al., 2016). One study (14.3%) reported significant decreases in well-being following an exergaming intervention using sport- and dance-based games played via Nintendo Wii (Rosipal et al., 2013). Three studies (42.9%) reported no change in well-being in a single-group post-test only assessment following an exergaming intervention (Chao et al., 2014; Tseng and Hsieh, 2013; Wall et al., 2015).

Discussion

The aim of this study was to synthesize the published evidence attesting to the role of exergaming in promoting well-being. To address this aim, we conducted a review of published studies (English language only) that reported exergaming as an intervention along with an index of well-being as a key study outcome. A comprehensive search and multi-phase filtering strategy resulted in 24 published studies that met the *a priori* inclusion criteria used in this review. Overall, it appears that exergaming research targeting well-being in adults has relied on samples at later stages of the lifespan often living with at least one health condition. Nintendo Wii is the most popular console used to evaluate the contributions of exergaming to well-being. Considerable variability was evident in terms of study design that likely confounds the role played by exergaming for bolstering well-being in adults. Finally, it is worth noting that two major trends emerged from this review. First, it appears that exergaming can enhance well-being especially when compared to a 'do-as-you-do' (or non-exercise) condition. Second, exergaming does not appear to confer unique benefits to well-being when compared against other (perhaps 'traditional') interventions using exercise as a stimulus to change well-being in adults.

Perhaps the most important observation emerging from this review concerns the effects attributable to exergaming on markers of well-being displayed by adults living with (or without) health conditions. The published studies evaluated in this review make it apparent that exergaming has potential to improve well-being in adult gamers; yet, the net effects of using this intervention modality are not guaranteed. Thirteen of the coded studies provided no support for the role of exergaming in changing well-being, whereas nine studies using either between-groups or single-groups designs provided evidence that exergaming can promote well-being in adults. At best, the results of this review imply that exergaming 'could' improve well-being in adults yet using this technologically advanced intervention modality to exercise fails to guarantee enhanced well-being.

Considering that exergaming is touted by various organizations – such as the American College of Sports Medicine (Witherspoon, 2013) – as a health promotion tool it seems the findings reported in this study call into question the role of exergaming as a modality to promote well-being in adults. With this in mind, it seems reasonable to question the wide-spread use of exergaming as an approach to improving well-being via exercise when the evidence-base supporting this technique is equivocal at best. Several possible issues emerged from this review that may account for the equivocal findings that warrant further consideration to advance research on exergaming. First, it is evident that insufficient attention has been afforded to various issues that strengthen the integrity of research attesting to the role played by exergaming in boosting well-being. Reliance on single-group designs or post-test only assessments of well-being seriously limit causal inference due to a host of internal validity threats (Shadish et al., 2002). Overuse (or misuse) of statistical significance testing especially in small samples can propagate null findings within the literature concerning exergaming and well-being (Harlow et al., 1999). Finally, the measurement of well-being is challenging at best (Mack et al., 2016); yet the eclectic nature of the instruments chosen to assess this important outcome of exergaming highlighted by this review leaves much to be desired. Future studies could use more sophisticated research designs (e.g., randomized controlled trials with multiple post-test assessments of outcome variables, etc.), employ *a priori* statistical power analyses to bolster null-hypothesis testing approaches to data analysis, and be mindful of advances in the conceptualization and measurement of well-being to clarify the role of exergaming in promoting (or diminishing) well-being.

Several limitations of this review deserve attention coupled with plausible directions for future research to advance our understanding of the contributions to well-being stemming from exergaming. First, there is a limited number of published studies that have addressed the relationship between exergaming and well-being in adults. Future research could address this issue by testing the association between exergaming and well-being using both subjective indicators (e.g., self-report) and biological markers (e.g., interleukin-6). Second, the inclusion/exclusion criteria restricted the studies included this review to those published in English. It remains unclear if broadening the scope of the review to include grey literature (e.g., graduate theses, etc.) that may be less susceptible to publication bias plus studies published in any language other than English would alter the main findings of this review. Future studies could explore this issue in greater detail to address the generalizability of the findings reported in this study. Third, substantial heterogeneity emerged from the coding process for both intervention delivery (see Table 2) and the assessment of well-being. While this observation is wholly aligned with other physical activity intervention research focused on well-being as an outcome (see Mack et al., 2016, as an example), it remains a potential confound when trying to unravel the nature of the links between well-being and exergaming. Future work could address this issue, in part, by mandating greater detail and transparency in reporting of exergaming interventions - perhaps using the Consensus on Exercise Reporting Template (Slade et al., 2016) - to advance this vibrant research area.

Conclusions

Overall, the summary findings emerging from this review make it apparent that exergaming 'may' be a novel intervention approach that has the potential to foster well-being in adults. However, it is also evident that deploying exergames as an 'intervention tool' with adults neither guarantees improved well-being nor offers anything 'unique' as a stimulus beyond more traditional modes of exercise behaviour (e.g., walking in 'real' not 'virtual' spaces, etc.).

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Author's qualifications

The authors' qualifications are as follows: Ester S. Santos MA; Philip M. Wilson PhD; Diane E. Mack PhD.

References

Andersen, L. B., Mota, J., and Di Pietro, L. (2016). Update on the global pandemic of physical inactivity. *The Lancet*, *388*, 1255-1256. https://doi.org/10.1016/S0140-6736(16)30960-6.

Barry, G., van Schaik, P., MacSween, A., Dixon, J., and Martin, D. (2016). Exergaming (XBOX Kinect) versus traditional gym-based exercise for postural control, flow, and technology acceptance in healthy adults: A randomized controlled trial. *BMC Sports Science, Medicine & Rehabilitation*, *8*: 25. https://doi.org/10.1186/s13102-016-0050-0.

Chao, Y. Y., Scherer, Y. K., Montgomery, C.A., Lucke, K. T., and Wu, Y. W. (2014). Exergames based intervention for assisted living residents: A pilot study. *Journal of Gerontological Nursing*, *40*, 36-43. https://doi.org/10.3928/0098913 4-20140407-04.

Collado-Mateo, D., Dominguez-Muñoz, F. J., Adsuar, J. C., Merellano-Navarro, E., and Gusi, N. (2017). Exergames for women with fibromyalgia: A randomized controlled trial to evaluate the effects on mobility, skills, balance, and fear of falling. *PeerJ*, *20*: e3211. DOI 10.7717/peerj.3211 https://doi.org/10.7717/peerj.3211.

Conn, V. S., Hafdahl, A., R., and Brown, L. M. (2009). Meta-analyses of quality-of-life outcomes from physical activity interventions. *Nursing Research, 58,* 175-183. https://doi.org/10.1097/NNR.0b013e3181 99b53a.

Cooper, H. (1982). Scientific guidelines for conducting integrative research reviews. *Review of Educational Research*, *52*, 291 -302. https://doi.org/10.2307/1170314.

da Silva Alves, R., Iunes, D. H., Pereira, I. C., Borges, J. B. C., Nogueria, D. A., Silva, A. M., Lobato, D. F. M., and Carvalho, L. C. (2017). Influence of exergaming on the perception of cancer-related fatigue. *Games for Health Journal, 6,* 119-126. https://doi.org/10.1089/g4h.2016.0051.

da Silva Ribeiro, N. M., Ferraz, D. D., Pedreira, É., Pinheiro, Í., da Silva Pinto, A. C., Neto, M. G., Dos Santos, L. R., Pozzato, M. G., Pinho, R. S., and Masruha, M. R. (2015). Virtual rehabilitation via Nintendo Wii® and conventional physical therapy effectively treat post-stroke hemiparetic patients. *Topics in Stroke Rehabilitation*, *22*, 299-305. https://doi.org/10.1179/1074935714Z.00 00000017.

Daskalopoulou, C., Stubbs, B., Kralj, C., Koukounari, A., Prince, M., and Prina, A. M. (2017). Physical activity and healthy ageing: A systematic review and meta-analysis of longitudinal cohort studies. *Ageing Research Reviews, 38,* 6-17. https://doi.org/10.1016/j.arr.2017.06.003.

Douris, P. C., McDonald, B., Vespi, F., Kelley, N. C., and Herman, L. (2012). Comparison between Nintendo Wii Fit aerobics and traditional aerobic exercise in sedentary young adults. *The Journal of Strength & Conditioning Research, 26*, 1052-1057. https://doi.org/10.1519/JSC.0b013e31822 e5967.

Ekelund, U., Steene-Johannessen, J., Brown, W. J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A., and Lee, I. M. (2016). Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonized meta-analysis of data from more than 1 million men and women. *The Lancet*, *388*, 1302-1310. https://doi.org/10.1016/S0140-6736(16)30370-1.

Harlow, L. L., Mulaik, S. A., and Steiger, J. H. (1999). *What if there were no significance tests?* London, UK: Routledge Press.

Heath, G. W., Parra, D. C., Sarmiento, O. L., Andersen, L. B., Owen, N., Goenka, S., Montes, F., Browns, R. C., and the Lancet Physical Activity Series working Group. (2012). Evidence-based interventions in physical activity: Lessons learned from around the world. *The Lancet*, *21*, 272-281. https://doi.org/10.1016/S0140-6736(12)60816-2.

Herz, N. B., Mehta, S. H., Sethi, K. D., Jackson, P., Hall, P., and Morgan, J. C. (2013). Nintendo Wii rehabilitation ("Wii-hab") provides benefits in Parkinson's disease. *Parkinsonism & Related Disorders*, *19*, 1039-1042. https://doi.org/10.1016/j.parkreldis.2013.07.014.

Huang, H. C., Wong, M. K., Yang, Y. H., Chiu, H. Y., and Teng, C. I. (2017). Impact of playing exergames on mood states: A randomized controlled trial. *Cyberpsychology, Behavior, & Social Networking*, *20*, 246-250. https://doi.org/10.1089/cyber.2016.0322.

Jones, C. M., Scholes, L., Johnson, D., Katsikitis, M., and Carras, M. C. (2014). Gaming well: links between videogames and flourishing mental health. *Frontiers in Psychology*, *5*. http://dx.doi.org/10.3389/fpsyg.2014.00260.

Karahan, A. Y., Tok, F., Taşkin, H., Kuçuksaraç, S., Başaran, A., and Yildirim, P. (2015). Effects of exergames on balance, functional mobility, and quality of life of geriatrics versus home exercise programme: Randomized Controlled Study. *Central European Journal of Public Health*, *23*, s14-S18. https://doi.org/10.21101/cejph.a4081.

Karahan, A.Y., Tok, F., Yilidirim, P., Ordahan, B., Turkoglu, G., and Sahin, N. (2016). The effectiveness of exergames in patients with ankylosing spondylitis: A randomized controlled trial. *Advances in Clinical & Experimental Medicine*, *25*, 931-936. https://doi.org/10.17219/acem/32590.

Keogh, J. W., Power, N., Wooller, L., Lucas, P., and Whatman, C. (2014). Physical and psychosocial function in residential aged-care elders: effect of Nintendo Wii sports games. *Journal of Aging & Physical Activity*, *22*, 235-244. https://doi.org/10.1123/japa.2012-0272.

Kloos, A. D., Fritz, N. E., Kostyk, S. K., Young, G. S., and Kegelmeyer, D. A. (2013). Video game play (Dance Dance Revolution) as a potential exercise therapy in Huntington's disease: A controlled clinical trial. *Clinical Rehabilitation*, *27*, 972-982. https://doi.org/10.1177/0269215513487235.

Konstantinidis, E. I., Billis, A. S., Mouzakidis, C. A., Zilidou, V. I., Antoniou, P. E., and Bamidis, P. D. (2016). Design, implementation, and wide pilot deployment of FitForAll: An easy to use exergaming platform improving physical fitness and life quality of senior citizens. *IEEE Journal of Biomedical & Health Informatics*, *20*, 189-200. https://doi.org/10.1109/JBHI.2014.2378814.

Mack, D. E., Wilson, P. M., and Gunnell, K. E. (2016). Land of confusion: Unpacking the relationship between physical activity and well-being in individuals living with osteoporosis. *International Review of Sport & Exercise Psychology*, *10*, 212-229. https://doi.org/10.1080/1750984X.2016.1216149.

Mack, D. E., Wilson, P. M., Gunnell, K. E., Gilchrist, J. D., Kowalski, K. C., and Crocker, P. R. E. (2012). Health-enhancing physical activity: Associations with markers of well-being. *Applied Psychology: Health & Well-Being*, *4*, 127-150. http://dx.doi.org/10.1111/j.1758-0854.2012.01065.x.

Mackintosh, K. A., Standage, M., Staiano, A. E., Lester, L., and McNarry, M. A. (2016). Investigating the physiological and psychosocial responses of single-and dual-player exergaming in young adults. *Games for Health Journal*, *5*, 375-381. https://doi.org/10.1089/g4h.2016.0015.

Maillot, P., Perrot, A., Hartley, A., and Do, M. C. (2014). The braking force in walking: Age-related differences and improvement in older adults with exergame training. *Journal of Aging and Physical Activity*, *22*, 518-526. https://doi.org/10.1123/japa.2013-0001.

Monedero, J., Murphy, E. E., and O'Gorman, D. J. (2017). Energy expenditure and affect responses to different types of active video game and exercise. *PloS One*, *12*, e0176213. https://doi.org/10.1371/journal.pone.0176213.

Naugle, K. E., Naugle, K. M., and Wikstrom, E. A. (2014). Cardiovascular and affective outcomes of active gaming: using the Nintendo Wii as a cardiovascular training tool. *Journal of Strength and Conditioning Research,* *28*, 443-449. https://doi.org/10.1519/JSC.0b013e31829999c3.

Padala, K. P., Padala, P. R., Lensing, S. Y., Dennis, R. A., Bopp, M. M., Roberson, P. K., and Sullivan, D. H. (2017a). Home-Based Exercise Program Improves Balance and Fear of Falling in Community-Dwelling Older Adults with Mild Alzheimer's Disease:

A Pilot Study. *Journal of Alzheimer's Disease*, *59*, 1-10. https://doi.org/10.3233/JAD-170120.

Padala, K. P., Padala, P. R., Lensing, S. Y., Dennis, R. A., Bopp, M. M., Parkes, C. M., Garrison, M. K., Dubbert, P. M., Roberson, P. K., and Sullivan, D. H. (2017b). Efficacy of Wii-Fit on static and dynamic balance in community dwelling older veterans: A randomized controlled pilot trial. *Journal of Aging Research*, 1-9. https://doi.org/10.1155/2017/4653635.

Ribas, C. G., da Silva, L. A., Corrêa, M. R., Teive, H. G., and Valderramas, S. (2017). Effectiveness of exergaming in improving functional balance, fatigue and quality of life in Parkinson's disease: A pilot randomized controlled trial. *Parkinsonism & Related Disorders*, *38*, 13-18. https://doi.org/10.1016/j.parkreldis.2017.02.006.

Rosenberg, D., Depp, C. A., Vahia, I. V., Reichstadt, J., Palmer, B. W., Kerr, J., Norman, G., and Jeste, D. V. (2010). Exergames for subsyndromal depression in older adults: a pilot study of a novel intervention. *The American Journal of Geriatric Psychiatry*, *18*, 221-226. https://doi.org/10.1097/JGP.0b013e3181c534b5.

Rosipal, N. C., Mingle, L., Smith, J., and Morris, G. S. (2013). Assessment of voluntary exercise behavior and active video gaming among adolescent and young adult patients during hematopoietic stem cell transplantation. *Journal of Pediatric Oncology Nursing*, *30*, 24-33. https://doi.org/10.1177/1043454212461071.

Serber, E. R., Ciccolo, J., Palmer, K., Cobb, V., Tilkemeier, P. L., and Bock, B. C. (2016). The feasibility of exercise videogames for cardiovascular risk reduction among adults: a pilot for" Wii heart fitness". *The Journal of Sports Medicine & Physical Fitness*, *56*, 319-327. https://doi.org/10.1177/1352458514563593.

Shadish, W. R., Cook, T. D., and Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Boston, MA: Houghton Mifflin Co.

Şimşek, T. T., and Çekok, K. (2016). The effects of Nintendo WiiTM-based balance and upper extremity training on activities of daily living and quality of life in patients with sub-acute stroke: a randomized controlled study. *International Journal of Neuroscience*, *126*, 1061-1070. https://doi.org/10.3109/00207454.2015.1115993.

Slade, S. C., Dionne, C. E., Underwood, M., and Buchbinder, R. (2016). Consensus on Exercise Reporting Template (CERT): Explanation and elaboration statement. *British Journal of Sports Medicine, 50,* 1428-1437. http://dx.doi.org/10.1136/bjsports-2016-096651.

Staiano, A. E., Marker, A. M., Beyl, R. A., Hsia, D. S. Katzmarzyk, P. T., and Newton, R. L. (2017). A randomized controlled trial of dance exergaming for exercise training in overweight and obese adolescent girls. *Pediatric Obesity*, *12*, 120-128. https://doi.org/10.1111/ijpo.12117.

Stanmore, E., Stubbs, B., Vancampfort, D., da Bruin, E. D., and Firth, J. (2017). The effect of active video games on cognitive functioning in clinical and non-clinical populations: A meta-analysis of randomized controlled trials. *Neuroscience & Biobehavioral Reviews, 78,* 34-43. https://doi.org/10.1016/j.neubiorev.2017.04.011.

Sween, J., Flynnt Wallington, S., Shepperd, V., Taylor, T., Llanos, A. A., and Lauren, L. (2014). The role of exergaming in improving physical activity: A review. *Journal of Physical Activity & Health*, *11*, 864-870. https://doi.org/10.1123/jpah.2011-0425.

Tseng, W. C., and Hsieh, R. L. (2013). Effects of short-term active video game play on community adults: under International Classification of Functioning, Disability and Health consideration. *Chinese Medical Journal*, *126*, 2313-2319. https://doi.org/10.3760/cma.j.issn.0366-6999.20123272.

Viana, R. T., Laurentino, G. E. C., Souza, R. J. P., Fonseca, J. B., Silva Filho, E. M., Dias, S. N., Teixeira-Salmela, L. F., and Monte-Silva, K. K. (2014). Effects of the addition of transcranial direct current stimulation to virtual reality therapy after stroke: a pilot randomized controlled trial. *NeuroRehabilitation*, *34*, 437-446. https://doi.org/10.3233/NRE-141065.

Wall, T., Feinn, R., Chui, K., and Cheng, M. S. (2015). The effects of the Nintendo™ Wii Fit on gait, balance, and quality of life in individuals with incomplete spinal cord injury. *The Journal of Spinal Cord Medicine*, *38*, 777-783. https://doi.org/10.1179/2045772314Y.0000000296.

Warburton, D. E., Nicol, C., and Bredin, S. S. (2006). Health benefits of physical activity: the evidence. *Cmaj, 174*(6), 801-809. URL: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16534088.

Ware, J. E., and Sherbourne, C. D. (1992). The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. Medical Care, 30, 473-483. http://dx.doi.org/10.1007/BF03260127.

Wiese, C., Kuykendall, L., and Tay, L. (2017). Get active? A meta-analysis of leisure-time physical activity and subjective well-being. *The Journal of Positive Psychology*, 13, 57-66. https://doi.org/10.1080/17439760.2017.1374436.

Witherspoon, L. (2013). ACSM information on…Exergaming [PDF file]. Retrieved from https://www.acsm.org/docs/brochures/exergaming.pdf

World Health Organization (2002). World Health Organization Quality of Life-BREF. Department of Mental Health and Substance Dependence. World Health Organization. Geneva, Switzerland.