2016

Virtual Reality: An Evidence-Based Guide for Occupational Therapy

Grant Mitchell
University of North Dakota

Kyle Nelson
University of North Dakota

Recommended Citation

Mitchell, Grant and Nelson, Kyle, "Virtual Reality: An Evidence-Based Guide for Occupational Therapy" (2016). *Occupational Therapy Capstones*. 140.
https://commons.und.edu/ot-grad/140

VIRTUAL REALITY: AN EVIDENCE-BASED GUIDE FOR OCCUPATIONAL THERAPY

by

Grant Mitchell, MOTS

Kyle Nelson, MOTS

Advisor: Sclinda Janssen, PhD, OTR/L

A Scholarly Project

Submitted to the Occupational Therapy Department

of the

University of North Dakota

In partial fulfillment of the requirements

for the degree of

Master of Occupational Therapy

Grand Forks, North Dakota

May 14, 2016

This Scholarly Project Paper, submitted by Grant Mitchell and Kyle Nelson in partial fulfillment of the requirement for the Degree of Master's of Occupational Therapy from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done and is hereby approved.

Selinda Janssen, PhD, OTR/L
Faculty Advisor

April 22, 2016
Date

PERMISSION

Title Virtual Reality: An Evidence-Based Guide for Occupational Therapy

Department Occupational Therapy

Degree Master of Occupational Therapy

In presenting this Scholarly Project in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, we agree that the Department of Occupational Therapy shall make it freely available for inspection. We further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised our work or, in her absence, by the Chairperson of the Department. It is understood that any copying or publication or other use of this Scholarly Project or part thereof for financial gain shall not be allowed without our written permission. It is also understood that due recognition shall be given to us and the University of North Dakota in any scholarly use which be made of any material in our Scholarly Project Report.

Signature__________________ Date 4-21-16

Signature Kyle Nelson Date 4-21-16

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The authors would like to thank our advisor, Dr. Sclinda Janssen, for encouraging us as if we were changing the world, yet still pushing us to work harder. We want to thank our family for support in editing, modeling, and listening to us talk about virtual reality. We want to especially thank the loved ones near to us for sacrificing time spent with us. Working on this project has developed our professional confidence. When you are passionate about your work, it is bearable to persist when the work becomes difficult.

ABSTRACT

Problem: Virtual reality (VR) is an emerging technology that serves to position the user in control of a virtual environment to maximize interest and function. VR is a context for intervention included in the Occupational Therapy Practice Framework: Domain and Process 3rd edition (OTPF-3; AOTA, 2014). It is crucial that occupational therapy (OT) practitioners enhance their knowledge about VR technology used by their clients to provide effective client-centered practice (AOTA, 2010). There is a lack of organization of the literature and research evidence regarding the use of VR as an intervention modality. While there has been a significant increase in recent literature supporting the use of VR in OT, there is a need for manuals and resources to guide clinicians in using VR as a therapeutic modality (Levac & Miller, 2013; Proffitt & Lange, 2015).

Methods: An extensive literature review for articles regarding the use of the Xbox Kinect and Nintendo Wii within OT was conducted using five databases. Relevant data was extracted from each article related to the use of the Xbox Kinect or Nintendo Wii in intervention to synthesize the findings into charts. The construction of the charts followed the organization of the OTPF-3 (AOTA, 2014).

Product: The authors of this product created an evidence-based resource to guide OT practitioners' use of VR. The intended purpose of this product, Virtual Reality: An Evidence-Based Guide, is to assist OT practitioners' adaptation and/or modification of

VR activities to address individual client needs. Using this product as a guide to current knowledge and evidence regarding intervention in the context of VR, OT practitioners will be better equipped to make safe and effective choices. To further support development of literature regarding VR, the authors of this product recommended areas for future research.

CHAPTER I

INTRODUCTION

Virtual reality (VR) is a context and treatment modality being used by occupational therapy (OT) in innovative ways to provide intervention to clients (AOTA, 2014). Intervention provided by OT practitioners should be supported by evidence. Although there is an abundance of literature regarding VR in OT, there is no centralized organizational framework that can be utilized by OTs to identify evidence for effective use of VR. Levac and Miller (2013) and Proffitt and Lange (2015) describe the need for manuals and resources to guide the use of VR as a therapeutic modality. This product provides a framework for OT practitioners to locate and use relevant evidence in order to guide intervention.

Problem

VR as a new technology, is being used by OT in a variety of ways as the technology has become accessible (Bondoc, Powers, Herz, & Hermann, 2010; Sparkes-Griffin, 2013). Barriers to effectively implementing VR by therapists include the lack of time, knowledge, organization, and resources (Glegg et al., 2013; Levac & Miller, 2013; Proffitt & Lange, 2015). Despite the presence of numerous articles (more than 2,000 were located as potential for being used in this scholarly project) regarding the use of VR in OT, there is not a simple way for OT practitioners to access and incorporate this literature. This impedes addressing specific client needs with evidence-based practice. The only apparent method available to locate articles related to what OT practitioners would like to address, is through reading a multitude of articles in various databases and analyzing their application to the present situation.

Searching for relevant literature through databases requires effort and time from the OT practitioner. This is a challenge and concern for OT practitioners due to increasing productivity demands (Yamkovenko, 2015). The authors of this scholarly project conducted a literature review to better understand and confirm this need within occupational therapy.

Literature Review

The authors of this product conducted a literature review of current VR technologies and their use within the domain of OT (AOTA, 2014). There were numerous technologies identified in the literature including GestureTek, Oculus Rift, Xbox Kinect, Sony PlayStation EyeToy, Nintendo Wii, XavixPort Gloves and other custom created devices utilized by specific clinics. This availability of VR technologies allows for practitioners to address a variety of client conditions utilizing a variety of newly developed treatment methods. These devices allow for engagement in meaningful tasks within a safe environment, including both the clinic and home environments (Bondoc et al., 2013).

Benefits supported by the variety of VR devices available for practice include numerous populations and client factors that have been researched. Many of the identified benefits related to the participants' perceptions of enjoyment and motivation for their inclusion, as well as practitioner perceptions of their ease of use, usefulness, and evidence-based improvements. This demonstrates use of VR as a context to provide meaningful and purposeful activity (AOTA, 2014). However, many barriers for the inclusion of VR in OT were identified including; lack of familiarity with the VR systems, discrepancies against VR's use with certain populations, such as the elderly, lack of customization of consumer-end technologies, and a lack of organization of current literature to ensure appropriate use of VR in therapy. Lack of organization of the literature was the primary barrier the authors of this product addressed in developing an evidence-based guide regarding VR's use in OT titled, *Virtual Reality: An Evidence-based Guide for Occupational Therapy.*

Methodology

The development of this scholarly project required an organizational framework to direct the creation of the guide *Virtual Reality: An Evidence-based Guide for Occupational Therapy*, and to allow for simple implementation into practice. To meet these needs, the developers of this guide utilized the domain of the Occupational Therapy Practice Framework: Domain and Process, 3rd edition (OTPF-3; AOTA, 2014) as a categorization system. The OTPF-3 is an official document utilized by OT practitioners, students, and other members of healthcare to present and describe OT practice constructs (AOTA, 2014, S1). The domain of the OTPF-3 includes the *Aspects* (or sections) utilized in the guide including; occupations, client factors, performance skills, performance patterns, and context and environment (AOTA, 2014). The presentation of the domain of OT in this comprehensive manner allows for OT practitioners to apply its concepts across settings and populations.

The OTPF-3 presented as a superior choice for a guiding framework over other theoretical models and frames of reference within OT, which are often more specific to certain conditions, populations, settings, and/or treatment methods. Using the OTPF-3 as an organizational framework, therefore allows OT practitioners to have the freedom to additionally use preferred models and frames of reference as indicated by their populations and settings. The flexibility, objectivity, and comprehensiveness of the OTPF-3 allows for its application to all clients within all settings and situations (AOTA, 2014).

Following the identification of the organizing framework, the authors of this guide performed a rigorous review of the literature to identify and organize OT-related evidence pertaining to VR as a treatment modality. Five databases were searched for related articles based on previously identified search terms, inclusion criteria, and exclusion criteria. This search resulted in reviewing over 2000 abstracts to identify the articles' relevance to this product. Each article that met the inclusion criteria was then analyzed to retrieve pertinent information that was later entered as individual data entries. All pertinent evidence-based findings were then organized according to the OTPF-3 to form the stated product (AOTA, 2014).

Product

The result of this scholarly project includes a product to be utilized as an evidence-based guide to current VR-related literature. This guide can be interpreted by following the layout of its organizational framework, the domain of the OTPF-3. The product contains multiple sections including Occupations, Client Factors, Performance Skills, Performance Patterns, and Context and Environment, all from the OTPF-3, as well as an additional section for each Assessment Tools and Case Scenarios. Although Assessment Tools is not an aspect of the OTPF-3, the authors of this evidence-based guide created a section pertaining to these tools, as they are a key part of OT assessment and guiding intervention and often measure a multitude of components that are identified in the OTPF-3 (AOTA, 2014). The last section of Case Scenarios was created to provide examples of how each section can be utilized to identify literature pertaining to specific therapy goals in order to incorporate VR into therapy.

Summary

This guide was created to assist the OT practitioner in implementing effective use of VR as a treatment modality and context. There is a need for resources and guides organizing the evidence for effective use of VR which is further impeded by the barriers of lack of time and knowledge (Glegg et al., 2013; Levac & Miller, 2013; Proffitt & Lange, 2015). This need was confirmed through a review of the literature by the authors of this project. Following confirmation of this need, the authors utilized the OTPF-3 as an organizational framework to create a comprehensive guide titled *Virtual Reality: An Evidence-Based Guide for Occupational Therapy.* This guide serves to assist OT practitioners in locating relevant articles to apply VR within a variety of intervention situations. The literature exploring the use of VR within OT is discussed in Chapter II.

CHAPTER II

LITERATURE REVIEW

Introduction

Technology today is advancing medicine at an accelerating rate. Among modern types of technology is virtual reality (VR). The use of VR is promising in healthcare for practitioner training, evaluation, and intervention (AOTA, 2013; Foronda & Bauman, 2014; Luna-Oliva et al., 2013). In the field of Occupational Therapy (OT) VR can provide increased independence for everyday activities and motivation for participants through meaningful, purposeful, and engaging tasks (Bondoc et al., 2010; Chen et al., 2014; Sparkes-Griffin, 2013). A significant barrier to the use of VR for therapists is limited access to resources for learning how to use VR effectively (Levac & Miller, 2013; Proffitt & Lange, 2015). The purpose of this literature review is to describe VR technology, benefits, barriers, and efficacy of what OT practitioners currently use.

Types of Virtual Reality

VR technology is being increasingly incorporated into daily life through devices such as smartphones, televisions, and various forms of wearable technology. VR is a computer-generated environment, or interface, in which individuals can interact passively or actively. Within OT, VR is considered a context and environment where occupation takes place, and can also be used for therapeutic intervention (AOTA, 2014). *Augmented reality* is another term emerging in literature, which differs from VR in that the computer-generated renderings of objects are overlaid on the real-world environment and its components (Virtual Reality Society [VRS], 2015). The delineation of types of technology such as VR and augmented reality can be categorized in a variety of ways. For the purpose of this paper, VR will be used as a general term to describe an environment or context that is assisted by computer-generated images. Two common implementations of VR are a television or monitor and head-mounted displays. VR can be partially immersive, such as watching a television, or fully immersive as exemplified by goggles that cover a participant's full field of view, such as the Oculus Rift. Primary examples of types of time context include synchronous video such as a teleconference, which occurs in real time, and asynchronous video, such as a recorded lecture (AOTA, 2013). However, VR can occur in a simulated environment entirely. The primary examples of VR used by clinicians discussed in this literature review are the Xbox Kinect and Nintendo Wii. These consumer-based consoles have had a history of being affordable and therefore accessible.

Benefits of VR for OT practice

There are multiple benefits for the use of VR in OT for both interventions and assessment tools (DeMatteo, Greenspoon, Levac, Harper & Rubinoff, 2012). There is a growing body of evidence supporting the use of the VR as a therapeutic context. Underserved populations can be better accessed by OT practitioners with VR such as through the use of telehealth (AOTA, 2013). VR can also be a resource for home health OT practitioners or a method for home programming as consoles are becoming increasingly more common in households (Choi et al., 2014; Plow & Finlayson, 2014). As opposed to the large overhead costs of creating medical devices with poor versatility, consumer-based devices can already be found in households, which provides an effective opportunity to reach the clients. Another form of access VR generates is through promoting participation in physical or social activities for individuals with disabilities through modified or simulated environments (Park, Lee, & Ko, 2013). By changing the environment, VR provides control that can facilitate independence and success (AOTA, 2014). Greater control and ability to participate in the activities encourages motivation (Chen et al., 2014). Due to control and an increased chance of success, participants can engage in real-time practice of occupations or tasks related to occupation in meaningful, purposeful, and enjoyable ways (Salem, Gropack, Coffin, & Godwin, 2012). Through simulation with the VR systems that create non-contact engagement in activities, VR can be a safe environment for clients to trial activities (Farrow & Reid, 2004; Plow & Finlayson, 2014; Salem et al., 2012; Saposnik et al., 2010; Williams, Doherty, Bender, Mattox, & Tibbs, 2011).

Both OT practitioners and clients have described VR as beneficial. Researchers have found VR can be a flexible tool in clinical practice, as it is both affordable and easily accessible (Farrow & Reid, 2004; Gutiérrez et al., 2013; Luna-Oliva et al., 2013; Plow & Finlayson, 2014; Williams et al., 2011; Yip & Man, 2013). OT practitioners have also stated that VR is beneficial because it promotes increased motivation through various activities such as games (HyeonHui & GyuChang, 2013; Nam-Yong, Dong-Kyu, & Hyun-Seung, 2015), dancing (Nam-Yong et al., 2015), walking simulation (Lloréns, Gil-Gómez, Alcañiz, Colomer, & Noé, 2015) and role playing (Kandalaft, Didehbani, Krawczyk, Allen, & Chapman, 2013). Lastly, practitioners have expressed that VR is especially useful because it promotes engagement in physical activity (Celinder & Peoples, 2012; Plow & Finlayson; 2014). Similar to positive aspects identified by researchers and OT practitioners, participants have expressed their own opinions of the use of VR in therapy.

Perhaps more important to the use of VR in therapy than OT practitioners' perspectives are the participants' perspectives of VR. Researchers found positive opinions for the use of VR in therapy by clients for as it is: engaging (Celinder & Peoples, 2012; Chen et al., 2014; Plow & Finlayson, 2014), enjoyable and fun (Chen et al., 2014; DeMatteo et al., 2012; Deutsch et al., 2013; Plow & Finlayson, 2014), able to sustain attention for a length of time (Farrow & Reid, 2004), and adds variety to the day (Celinder & Peoples, 2012). Other participants stated they enjoyed tracking progress with the Wii (Plow & Finlayson, 2014) and were able to increase socialization through the use of VR's (Williams et al., 2011). For those who had limited involvement in activities due to disabilities, injuries, or illness, VR was a way to safely re-engage in lost activities, such as golf and exercise, within their own home or in therapy. (Farrow & Reid, 2004; Plow & Finlayson, 2014). This re-engagement in lost activities may increase participants' self-esteem through their being able to identify themselves as active and able to engage in physical activities. This also can reassure participants of the abilities and health they still possess (Plow & Finlayson, 2014). When used as an assessment tool for recognizing a children’s readiness to return to physical activity following a traumatic brain injury, the children preferred VR over standardized assessments (DeMatteo et al., 2012). Lastly, participants in a study by Plow and Finlayson (2014) enjoyed the use of the Wii over other forms of VR activities due to its lack of violence that is often stereotyped in gaming activities. The variety of positive opinions regarding the use of VR demonstrates an increased demand for OT practitioners and researchers to be knowledgeable on its appropriate and evidence-based use within clinical practice.

Client Populations for VR

The versatility of using the VR context for intervention allows it to be adapted to meet the needs of a variety of client populations. Researchers have found evidence supporting the use of VR with individuals affected by a variety of diagnoses (Table 1). While different conditions require different approaches to the use of VR, this spectrum indicates a likelihood of undiscovered efficacy with other populations.

Table 1: Diagnoses addressed using VR

Population	References	General Findings
Stroke	Celinder & Peoples, 2012; Chen et al., 2014; Choi et al., 2014; Deutsch et al., 2013; Farrow & Reid, 2004; HyeonHui & GyuChang, 2013; Lloréns, Gil-Gómez, Alcañiz, Colomer, & Noé, 2015; Saposnik et al., 2010	While the stroke population is a major category for VR research, significant results remain limited. Positive improvements have been found in a variety of physical client factors due to the movement-based activities. With the stroke population, VR has been as effective as traditional OT in treating symptoms of stroke but has been shown to be an excellent tool in addition to traditional rehabilitation.
Cognitive	Chang, Kang, & Huang,	VR worked as a prompting device in the

impairment	2013	workplace demonstrating potential as an effective tool for job skills training and vocational support.
Traumatic brain injury	DeMatteo et al., 2012; Levac & Miller, 2013; Yip & Man, 2013	VR was used as an assessment tool for pediatrics prior to the return of physical activities post injury, though had limited support for addressing balance. VR can be effective at both memory training and providing compensatory strategies for daily function. VR is motivating, accessible at home for home treatment, applicable to assess exertion, but currently lacks customizability for this population.
Multiple sclerosis	Gutiérrez et al., 2013; Plow & Finlayson, 2014	As an alternative means to exercises, VR can be a way to gain an identity as someone who exercises which can be prohibited by symptoms of MS. Use of VR for MS treatment resulted in similar results to standard therapies to address balance and posture. A benefit for individuals with MS, is VR can be used at home and activities can be trialed prior to attempting them in the natural setting. However, participants expressed a need for customizability and

		concerns for falling prompting researchers to encourage continued understanding of the efficacy and safety of VR use with this population.
High functioning autism	Kandalaft, Didehbani, Krawczyk, Allen, & Chapman, 2013	Researchers examined the use of VR as a tool for developing social skills in individuals with autism. The researchers found the results to be positive but not significant.
Cerebral palsy	Luna-Oliva et al., 2013	Treatment using VR movement games in addition to traditional physiotherapy was effective for children with cerebral palsy (CP) to address a variety of physical client factors.
Developmental delay	Salem et al., 2012	The Wii is beneficial to address deficits in single-leg stance, grip, and strength for children with developmental delays. The Wii was also safe, feasible, and beneficial to this population.
Parkinson's	Nam-Yong, Dong-Kyu, & Hyun-Seung, 2015	VR can be a multifaceted intervention tool for treatment of Parkinson's addressing balance, ADLs, and depression.
Chronic low back pain	Park, Lee, & Ko, 2013	The researchers of this study compared the use of the Wii to lumbar stabilization exercises. Wii

		was found to have beneficial impact on pain, quality of life, and mental health.
Well elderly	Williams et al., 2011	The use of the Wii with the well elderly population facilitated improvement with balance, the Wolf Functional Motor Test, grip strength, and the Box and Block Test promoting increased ability to complete daily tasks.
Depression	Nam-Yong et al., 2015; Park, Lee, & Ko, 2013	The use of VR by providing a motivating and accessible means to activity has had significant positive results in mental health including decreasing depression symptoms and increasing quality of life.

Client Factors Addressed by VR

The client factors addressed with the use of VR can be both cognitive and physical as demonstrated in Table 2. Following simulated practice with VR systems to address any deficits in client factors, ADLs can be addressed with a transition to occupation-based activity following the guidance of a therapist

Table 2: Client Factors addressed using VR

Client Factor	References	General Findings
Gross movement activity facilitating balance	DeMatteo et al., 2012; Lloréns et al., 2015; Luna-	VR use resulted in positive, but weak results for the majority of

	Oliva et al., 2013; Nam-Yong et al., 2015; Park, Lee, & Ko, 2013; Salem et al., 2012; Williams et al., 2011	studies when addressing balance with the primary benefit being greater control and safer practice environment.
Core strength	Park, Lee, & Ko, 2013	The researchers of this study found the Wii effective, but less so than stabilization exercises for core strength.
Endurance	DeMatteo et al., 2012; Park, Lee, & Ko, 2013; Williams, et al., 2011	The Wii was beneficial and appropriate to measure exertion ability in children with TBI for return to safe daily activity. Both energy and endurance can be progressed with the use of the Wii.
Lower extremity (LE) function including gait, running, jumping, stepping	Luna-Oliva et al., 2013; Salem et al., 2012; Plow & Finlayson, 2014	VR was beneficial for improving LE function in individuals with Parkinson's Disease and children with developmental delay. Individuals with MS also reported they perceived the use of the Wii to be appropriate and beneficial overall when used to address LE

		functions.
Upper extremity (UE) function including fine motor/manual dexterity, grip, and coordination	Chen et al., 2014; Choi et al., 2014; Luna-Oliva et al., 2013; Saposnik et al., 2010	The use of VR to address UE function is controversial, with Luna-Oliva et al. (2013) and Chen et al. (2014) stating that there is potential for VR's use, yet insignificant results, and Saposnik et al. (2010) stating VR was able to improve results on the WOLF functional Motor test, grip strength, and the Box and Block Test at a significance level.
Mental functions including; attention, visual-spatial, memory, and social skills	Kandalaft et al., 2013; Yip & Man, 2013	The versatility of VR can be utilized with different programs, applications, and games to address these client factors. The ability to modify the task for the participants is critical to the effectiveness of VR in this context.

Barriers for VR in OT Practice

The use of VR as a treatment modality is a relatively recent advent with a growing body of literature surrounding efficacy with its use. System consoles such as the Nintendo Wii and Xbox Kinect have only recently provided movement-based games that can target physical interaction aside from a handheld controller. Due to the novelty of this technology, a variety of barriers and challenges currently exist. The primary barriers found during this literature review included: practitioner familiarity, generational discrepancies, lack of customizability, and lack organization of current literature. These barriers prevent practitioners from effective incorporation and utilization of VR.

Practitioner familiarity.

The immediate challenge to the effective use of VR is the training and familiarity with the system consoles (Levac & Miller, 2013). While OT practitioners are required to remain up to date with current technology, many practicing clinicians have had little experience with VR systems and report a need for training and resources (AOTA, 2014; Glegg et al., 2013). A challenge with using VR systems that may also be affected by lack of familiarity is the time required to set up and maintain the system consoles (Levac & Miller, 2013). With the pressure of time constraints and productivity standards, turning on and game set up can be a significant barrier. Active games, such as Wii Sports and Kinect Dance, have space demands that complicate the mobility of game systems and increase practitioner familiarity with additional demands that may not have been anticipated. These demands for practitioner familiarity with the VR systems complicate their use within therapy.

Generational discrepancies.

There is a generational discrepancy with participants' motivation to participate in VR-related activities. The geriatric population may be more likely to experience lack of interest while the pediatric population may experience an over interest or a preference for the use of VR over other interventions (Dematteo et al., 2012; Levac & Miller, 2013). Other individuals may not express an interest in VR due to the extreme challenges presented to those with limited abilities. Due to the lack of ability to grade the activities, participants may not enjoy the use of VR due to activities being too challenging (Plow & Finlayson, 2014). VR has been found to be motivating and meaningful to many clients, but OT practitioners will still have to use clinical judgment to determine the use of VR on an individual basis. A common use of VR in the pediatric population is as a reward or motivator, which creates new practical and ethical challenges. One challenge is promoting a reduced interest in other interventions occurring in the pediatric population, which may have similar effects in individuals with cognitive impairments (Levac & Miller, 2013). Lack of motivation, while requiring assessment on an individual basis, may present to be a barrier to the use of VR in therapy.

Lack of customizability.

Another barrier with the use of VR is the limited ability to modify and individualize treatment activities using existing games and system consoles (Levac & Miller, 2013). Farrow and Reid (2004) discuss this issue with their use of the Xbox Kinect and the inability to grade the activities to match the participant’s abilities. The inability to modify game controls and demands to match the client’s needs can lead to user frustration (Plow & Finlayson, 2014). This inability creates a barrier to providing the appropriate challenge to match specific client factors. It is critical to the efficacy and ethical use of VR by OT's to clearly identify the specific client factors being addressed in intervention, and how they are specifically being met through the use of VR through individualized treatment. Despite the potential of VR as a useful tool in collecting objective treatment data, this lack of customizability presents a barrier for its ethical use within therapy.

Lack of literature organization.

The last barrier for the use of VR systems in therapy includes the lack of organization of current literature and evidence, results that are not significant, the need for skilled therapist input when VR is used in intervention. Multiple studies demonstrated a lack of significant difference between control groups and VR groups; however, others demonstrated that VR was not beneficial. Choi et al. (2014) found no improvement in grip strength, DeMatteo et al (2012) found no ability to assess balance with VR, and Park, Lee, and Ko (2013) found no improvement in fine motor skills and abilities. The presence of research with insignificant results dictates that if VR is to be used in treatment, research that supports its use must be either located or conducted. For treatment planning and billing, identification of a strong rationale can be challenging without protocols, resources, and the support of research to guide therapist interventions. Lastly, the use of VR as a therapeutic intervention does not replace the therapist's involvement (Bondoc et al., 2010; Salem et al., 2012), but increases the need for knowledge that OT practitioners must have to use VR therapeutically. OT practitioners must understand how to modify and chose VR activities that address the needs of their participants. Currently, no organization of the research and literature exists to guide OT practitioners on how to correctly use VR within therapy for the benefit of their participants.

Summary

VR's use in therapy and medicine is increasing due to technological advances improving accessibility, versatility, and function. A variety of VR devices currently exist, including the consumer-oriented Nintendo Wii and Xbox Kinect. These VR systems have benefits that demonstrate their potential as a safe, therapeutic context, as well as through providing a variety of activities, games, and tasks for clinical practice. The use of VR supports reaching a diverse population to address a variety of client factors while continuing to individualize treatment. However, barriers to the use of VR as a clinical tool in OT practice include: practitioner familiarity, general discrepancies, a lack of customizability, and a lack of organization of VR literature supporting positive outcomes with clinical use. The purpose of this scholarly project will be to organize current research and evidence regarding the use of VR in OT into a single product, *Virtual Reality: An Evidence-Based Guide for Occupational Therapy,* to promote safe, ethical, and evidence-based use of VR by OT practitioners. The methods of the creation of this scholarly project are discussed in Chapter III.

CHAPTER III

METHODS

Research

The creation of this scholarly project began with a literature review of VR use in practice. Upon identifying the benefits, barriers, and needs related to effective use of VR in practice by OT practitioners, the authors of this guide redesigned a comprehensive literature review to begin the development of the guide *Virtual Reality: An Evidence-Based Guide for Occupational Therapy*. The development of the product began with the search of existing literature pertaining to the use of the Nintendo Wii and Xbox Kinect virtual reality (VR) systems within interventions that address the domain of occupational therapy (OT). A systematic process was completed to review the following databases available through the University of North Dakota: Pubmed, Cinahl, OT Search, Academic Search Premier, and Scopus. Within each of the databases, the following term combinations were used: “Occupational therapy AND virtual reality,” “Occupational therapy AND Xbox,” and “Occupational therapy AND Wii.” Additional parameters for searches were included to reduce the number of articles that were not applicable to this product. These parameters included setting the language to English and the publication date to no earlier than 2005, which was the year the Nintendo Wii was released to the market. The Xbox Kinect was released at a later date. Table 3 indicates the number of articles located within each search engine to be reviewed for potential use within the product.

Table 3. Number of article retrieved within each database

Database	"Occupational therapy AND virtual reality"	"Occupational therapy AND Xbox"	"Occupational therapy AND Wii"
Pubmed	124	5	25
Cinahl	70	1	12
OT Search	13	0	0
Academic Search Premier	131	6	17
Scopus	1287	33	321

Articles that were listed within each search engine were individually reviewed to meet the following inclusion and exclusion criteria.

- Inclusion Criteria: Published after 2005, utilized the Nintendo Wii and/or the Xbox Kinect, the research pertained to the intervention process, the area of intervention studied was within the Domain of OT as determined by the "Occupational Therapy Practice Framework: Domain and Process 3rd Edition" (OTPF-3; American Occupational Therapy Association [AOTA], 2014), the article was in the English language, it was an original research article.
- Exclusion Criteria: Published prior to 2005, did not utilize the Nintendo Wii and/or the Xbox Kinect, the area of intervention was not within the domain of OT as determined by the OTPF-3 (AOTA, 2014), the research was a study of the use of the VR system as an assessment tool, and the use of VR was not the primary focus of the researchers, the authors focus was on therapists' perceptions of VR, or the article was a systematic review or review of literature.

If the criteria were met, the article was put on a master list for the authors of this guide to later extract relevant information the article was downloaded in electronic version to be placed in a master folder for later retrieval. A total of 2045 articles were reviewed, including duplicates of articles that appeared within multiple databases. A total of 69 articles met the criterion to be included within the product.

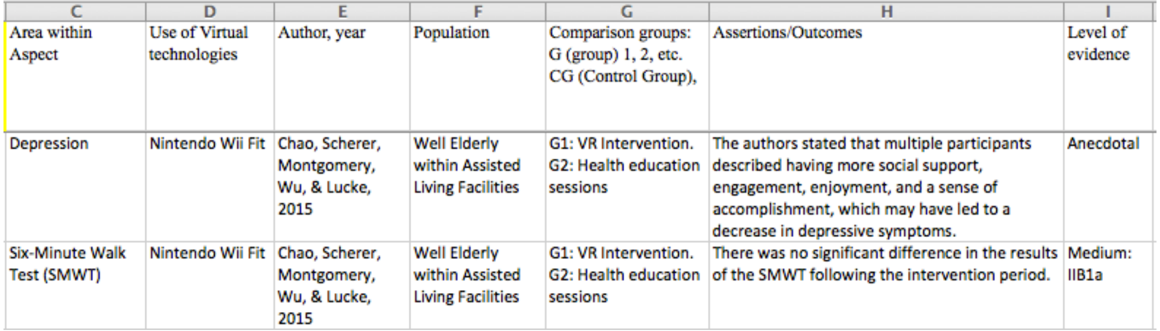
Framework

The "Occupational Therapy Practice Framework: Domain and Process 3rd edition" (OTPF-3) was utilized as the guiding framework for the completion of the product (AOTA, 2014). The OTPF-3 organizes the fundamental and universal concepts of OT to establish a common language and vision for the profession, which is included in the *Domain* and *Process* (AOTA, 2014). The *Domain* describes the scope of OT and the areas that OT's possess expertise. The *Process*, describes the various actions OT's possess the skills to perform. The *Domain* of the OTPF-3 is divided into various aspects including Occupations, Client Factors, Performance Skills, Performance Patterns, and Contexts and Environments (AOTA, 2014). Within each of these aspects are various components of the *Domain* that were extracted from articles as data. For example, within the *Performance Skills* aspect is the skill of coordination (AOTA, 2014), and if researchers studied the impact of VR on addressing an individual's coordination, then their conclusions of an increase, decrease, or no change were extracted as data to be synthesized.

Coding of Information

In order to integrate the articles within the product, each article was individually reviewed to extract the data. The data was then placed on a Microsoft Excel spreadsheet, with each data point having its own line. The data extracted from the articles included primary and secondary outcome measures within the domain of OT and ranged from specific client factors, such as balance, to overall standardized test results, such as the Fugle-Meyer Assessment. Below is a sample of the data layout (See figure 1).

Figure 1. Data organization into the chart

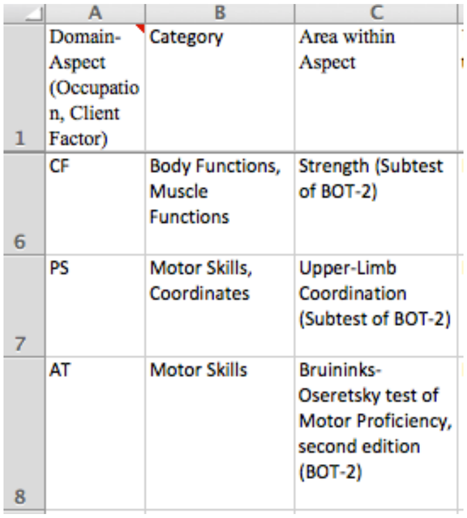


C	D	E	F	G	H	I
Area within Aspect	Use of Virtual technologies	Author, year	Population	Comparison groups: G (group) 1, 2, etc. CG (Control Group),	Assertions/Outcomes	Level of evidence
Depression	Nintendo Wii Fit	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly within Assisted Living Facilities	G1: VR Intervention. G2: Health education sessions	The authors stated that multiple participants described having more social support, engagement, enjoyment, and a sense of accomplishment, which may have led to a decrease in depressive symptoms.	Anecdotal
Six-Minute Walk Test (SMWT)	Nintendo Wii Fit	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly within Assisted Living Facilities	G1: VR Intervention. G2: Health education sessions	There was no significant difference in the results of the SMWT following the intervention period.	Medium: IIB1a

After each data point was entered, it was categorized into the Aspect (ie. Occupation, Client Factor, Performance Skill, Performance Pattern, Context and Environment) of the *Domain* it correlated with and which category of the selected Aspect it was placed (AOTA, 214). Due to the fact researchers of the articles retrieved may not have been directly addressing the categories of the OTPF-3, the standardized tests utilized in their research were also included as another category. If the article gave results pertaining to subtests of the assessment tool, this subtest/category was also categorized as a new data point. For example, within the Bruininks-Oseretsky test of Motor Proficiency-second edition (BOT-2) are the subtests of strength and upper limb coordination.

Each data point (overall BOT-2 results, strength subtest, and Upper-Limb Coordination subtest) was interpreted as an individual data point and categorized accordingly (See figure 2). There were a total of 306 data points retrieved and integrated into the product.

Figure 2. Data point categorization



	A	B	C
1	Domain-Aspect (Occupation, Client Factor)	Category	Area within Aspect
6	CF	Body Functions, Muscle Functions	Strength (Subtest of BOT-2)
7	PS	Motor Skills, Coordinates	Upper-Limb Coordination (Subtest of BOT-2)
8	AT	Motor Skills	Bruininks-Oseretsky test of Motor Proficiency, second edition (BOT-2)

Level of Evidence

Each article was also assigned a level of evidence to assist practitioners in determining which articles may be more trustworthy and generalizable. Trombly, et al. (1999) developed the table used to determine the level of evidence of the research articles (as cited by Lieberman and Scheer, 2002). Based on Trombly et al.'s (1999) levels of evidence, the authors of this guide rated the articles as High (Level IA, IB, IIA), Medium (Level IIB, IIIA, IIIB), and Low (Level IV, NA). The authors of this guide also added an additional level termed "Anecdotal" which consists of changes or improvements reported or noted by the researchers and research participants but were not included in the qualitative or quantitative data recorded.

Integration into Product

At the completion of the coding, the entire table was organized using the "Sort" tool within Microsoft Excel according to the aspect of the OTPF-3 (AOTA, 2014), then by category of each aspect, area within the category, level of evidence, author, and year. Each data set was then placed into the appropriate table and table section within the product as organized by the OTPF-3 (AOTA, 2014). Based on this process as described in this chapter, relevant articles from 5 databases have been analyzed and coded into a comprehensive guide of the evidence regarding the use of VR in OT. Chapter IV contains the results of this process and describes the *Virtual Reality: An Evidence-Based Guide for Occupational Therapy*.

CHAPTER IV

PRODUCT

The purpose of this product is to provide OT practitioners with simple access to evidence-based literature regarding the use of VR in practice. This product, *Virtual Reality: An Evidenced-Based Guide for Occupational Therapy,* serves as the evidence-based resource to the literature to allow OT practitioners to identify specific articles that will assist them in integrating VR into therapy.

The *Virtual Reality: An Evidenced-Based Guide for Occupational Therapy* contains seven sections. Five of these sections pertain to each aspect of the OTPF-3 including: 1) Occupations, 2) Client Factors, 3) Performance Skills, 4) Performance Patterns, and 5) Context and Environment (AOTA, 2014). The next section, 6) Assessment Tools, pertains to assessment tools that are utilized to gather information that may relate to multiple of the previous five sections, and does not fit into a single category from above. Each of the first six sections contains a chart in table format that serves to organize the literature within each of the aspects of the OTPF-3 (AOTA, 2014). The last section, 7) Case scenarios, provides examples of how the *Virtual Reality: An Evidenced-Based Guide for Occupational Therapy* may be utilized to locate and integrate research into practice to meet specific client needs.

The OTPF-3 was selected as an organizational framework due to its ability to be applied to a large variety of clients and setting (AOTA, 2014). It is also applicable as the OTPF-3 organizes various person aspects that may be addressed through the therapeutic process, and can be used in conjunction with other theories and models that will guide the approach to how the identified person aspects are addressed.

This product is intended to be used as a guide to the literature pertaining to various person components. As each therapy situation presents unique aspects to be addressed, OT practitioners wishing to utilize VR with their clients must refer to the literature to determine if the present situation is supported by research evidence. To locate articles specific to their situation, OT practitioners may find it useful to utilize the *Virtual Reality: An Evidenced-Based Guide for Occupational Therapy* as it presents the results of various research articles pertaining to client components identified within the OTPF-3 (AOTA, 2014). Some of the components, such as *balance*, have a multitude of articles that examine the effects of VR on their outcome. Therefore, this product presents each of the located articles, as well as their outcomes, populations addressed, level of evidence, and the type of VR system used. By examining these charts, the OT practitioner will be presented with options and can decide which article to utilize based on their situation. This eliminates the OT practitioner's need to perform their own time-consuming search of any databases they may have available to them for articles that may or may not be beneficial to their situation.

The authors possess three main goals related to implementation of this product. These goals are: 1) to make the product available for practitioners to use through marketing, 2) to update the current information as the research evidence grows, and 3) to expand the information to other types of VR systems. The first goal is to position this product where it will be easily accessible to OT practitioners for reference. Potential methods to accomplish this task include publishing the product in paper format, publishing as an online PDF, or publishing it as a website tool that is always accessible. Due to the second goal, which is to frequently update the information that is constantly evolving, the ideal format for making the product available is a website or similar format that can be easily updated and is readily available. The third goal is to expand the VR systems addressed. The current product only contains research addressing the use of the Xbox Kinect and Nintendo Wii, two VR systems available to consumers that are used within rehabilitation. Through expanding the product, many more systems that are both consumer-based, as well as rehabilitation-specific can be added and available to OT practitioners.

The product, *Virtual Reality: An Evidenced-Based Guide for Occupational Therapy*, can be found in the Appendix. The product, along with other chapters of this scholarly project, was developed in fulfillment of the requirements for the Master of Occupational Therapy degree at the University of North Dakota. The references used within the product can be found at the end of the product within the product's references section, which is separate from the references for the overall scholarly project.

This chapter, Chapter IV, examined the overall purpose and content of the product. Chapter V will present a summary of the scholarly project.

CHAPTER V

SUMMARY

Discussion

New technology, including VR, is being increasingly incorporated into daily activity. The Nintendo Wii and Xbox Kinect are examples of consumer VR products that are affordable, accessible, and feasible for use by the public and as a treatment modality by OT practitioners. VR is both a context in which treatment can take place, and a treatment modality requiring evidence-based support for its use (AOTA, 2014). Glegg et al., (2013), listed a lack of time and lack of knowledge as the most reported barriers to OT practitioners' use of VR, decreasing practitioner self-efficacy with VR use.

Despite the presence of more than 2,000 VR-related articles, there is a lack of literature organizing this evidence to guide therapists in clinical use of VR (Levac & Miller, 2013; Proffitt & Lange, 2015). This evidence-based guide was created utilizing the OTPF-3 as a theoretical framework (AOTA, 2014). The aspects of the OTPF-3 were utilized to create sections of the guide containing data from research articles pertaining to occupations, client factors, performance skills, performance patterns, context and environment, and the assessment tools used to measure the treatment outcomes. An additional section of case scenarios was created to provide examples of how to utilize the guide within practice. It is recommended that OT practitioners utilize this guide to locate current evidence supporting positive outcomes in utilizing VR as a treatment modality.

Implications

This product, *Virtual Reality: An Evidence-Based Guide for Occupational Therapy,* will benefit OT practitioners in providing a guide to the research regarding effective implementation of VR systems including the Nintendo Wii and Xbox Kinect. These two VR systems are accessible, feasible, and common technology available to the public. The authors of this guide found themes in the evidence for positive outcomes related to motivation, social interaction, and movement based outcomes. However, the practitioner will continue to need clinical reasoning skills to appropriately match the use of VR technology to the client. It is recommended that OT practitioners implement this guide with the various populations and settings reflected in the literature. Methods for marketing this guide to OT practitioners include publishing the guide, providing an accessible portable document format (PDF), or creating a website to display the organized evidence. OT practice would benefit from continued research and data guiding positive outcomes and evidence-based practice with VR use.

Limitations

Limitations for this product include the exclusion of alternative VR methods such as the iPad or third party software products. As VR changes and evolves, this new technology will require continuous research supporting its feasibility, safety, ethical concerns, and treatment outcomes. Despite supporting evidence, VR may not be an effective modality for all clients due to client preferences and perceptions of VR (Laver, Ratcliffe, George, Lester, & Crotty, 2013). While this product incorporates the OTPF-3 as a theoretical framework, additional models were not incorporated into the design of this guide due to the wide variety of populations and settings where this guide may be used. In addition, the OTPF-3 is the unifying conceptual model for OT practice. (AOTA, 2014)

Recommendations

With the current state of evidence, it is important that VR continues to be recognized as a context in which therapy takes place and not just an intervention alone (AOTA, 2014). The clinical reasoning of the OT practitioner remains critical to the effective fit of VR as a treatment modality with the aspects of the client addressed in the OTPF-3 (AOTA, 2014; Salem et al., 2012). VR systems such as the Nintendo Wii and Xbox Kinect have potential to be incorporated into effective home-based therapeutic activities. However, research is limited on the effect of these VR systems on adherence and efficacy in the home. This product would be an effective tool for clinical practice if it does not remain static, but is improved upon as evidence and technology changes. A follow-up qualitative study identifying barriers and benefits of this product is recommended.

The *Virtual Reality: An Evidence-Based Guide for Occupational Therapy* was created to assist the OT practitioner in implementing effective use of VR as a treatment modality and a context. A large body of literature exists regarding VR systems being used with a variety of populations and settings to promote positive outcomes, yet a lack of knowledge and a lack of organization of this literature inhibits OT practitioners from using VR. An extensive literature review was conducted regarding the use of two VR systems, the Nintendo Wii and Xbox Kinect, due to the availability and accessibility of these systems. The OTPF-3 (AOTA, 2014) was used to guide the organization of evidence retrieved due to the wide variety of populations and settings where VR can be used. By implementing this resource in clinical settings reflected in the literature, OT practitioners may have an organized way to guide intervention utilizing VR for positive outcomes such as motivation, movement-related functions, and social participation.

REFERENCES

American Occupational Therapy Association. (2010). Specialized knowledge and skills in technology and environmental interventions for occupational therapy practice. *American Journal of Occupational Therapy,* 64(6), S44-S56.

American Occupational Therapy Association. (2013). Telehealth. *American Journal of Occupational Therapy, 67*(Suppl. 1), S1– S48. http://dx.doi.org/10.5014/ajot.2014.682006

American Occupational Therapy Association. (2014). Occupational therapy practice framework: Domain and process (3rd ed.). *American Journal of Occupational Therapy, 68*(Suppl. 1), S1– S48. http://dx.doi.org/10.5014/ajot.2014.682006

Bondoc, S., Powers, C., Herz, N., & Hermann, V. (2010, June 28). Virtual reality-based rehabilitation. *OT Practice, 15*(11), CE1-CE8.

Bruininks, R. H. (1978). Bruininks–Oseretsky Test of Motor Proficiency: Examiner's manual. Circle Pine, MN: American Guidance Service.

Celinder, D. and Peoples, H. (2012). Stroke patients' experiences with wii sports during inpatient rehabilitation. *Scandinavian Journal of Occupational Therapy 19*(5) 457-463. doi: 10.3109/11038128.2012.655307

Chang, Y. J., Kang, Y. S., & Huang, P. C. (2013). An augmented reality (AR)-based vocational task prompting system for people with cognitive impairments. *Research in Developmental Disabilities, 34*(10), 3049-3056.

Chen, M., Huang, L., Lee, C., Hsieh, C, Lin, Y., Lui, H., Lu, W. (2014) A controlled pilot trial of two commercial video games for rehabilitation of arm function after stroke. *Clinical Rehabilitation 28*(10), doi: 10.1177/0269215514554115

Choi, J., Han, E., Kim, B., Kim, S., Im, S., Lee, S., Hyun, C. (2014) Effectiveness of commercial gaming-based virtual reality movement therapy on functional recovery of upper extremity in subacute stroke patients. *Annals of Rehabilitation Medicine. 38*(4), 485-493. doi: 10.5535/arm.2014.38.4.485

DeMatteo, C., Greenspoon, D., Levac, D., Harper, J., & Rubinoff, M. (2012). Evaluating the Nintendo Wii for assessing return to activity readiness in youth with mild traumatic brain injury. *Physical and Occupational Therapy in Pediatrics, 34*(3), 229-244. Doi: 10.3109/01942638.2014.885103

Deutsch, J. E., Myslinski, M. J., Kafri, M., Ranky, R., Sivak, M., Mavroidis, C., & Lewis, J. A. (2013). Feasibility of virtual reality augmented cycling for health promotion of people poststroke. *Journal of Neurologic Physical Therapy, 37*(3), 118-124. doi:10.1097/NPT.0b013e3182a0a078

Farrow, S., Reid, D. (2004). Stroke survivors' perceptions of a leisure-based virtual reality program. *Technology and Disability 16*(2), 69-81.

Foronda, C., & Bauman, E. B. (2014). Strategies to Incorporate Virtual Simulation in Nurse Education. *Clinical Simulation in Nursing, 10*(8), 412-418 7p. doi:10.1016/j.ecns.2014.03.005

Glegg, S. M. N., Holsti, L., Velikonja, D., Ansley, B., Brum, C., Sartor, D. (2013). Factors influencing therapists' adoption of virtual reality for brain injury rehabilitation. *Cyberpyscyhology, Behavior, and Social Networking, 16*(5), 385-401 doi: 10.1089/cyber.2013.1506

Gutiérrez, R. O., Galán del Río, F., Cano de la Cuerda, R., Alguacil Diego, I. M., González, R. A., & Page, J. M. (2013). A telerehabilitation program by virtual realityvideo games improves balance and postural control in multiple sclerosis patients. *Neurorehabilitation, 33*(4), 545-554. doi:10.3233/NRE-130995

Sin, HH., & Lee, GC. (2013). Additional virtual reality training using Xbox Kinect in stroke survivors with hemiplegia. *American Journal of Physical Medicine & Rehabilitation, 92*(10), 871-880. doi:10.1097/PHM.0b013e3182a38e40

Kandalaft, M., Didehbani, N., Krawczyk, D., Allen, T., & Chapman, s. (2013). Virtual reality social cognition training for young adults with high-functioning autism. *Journal of Autism & Developmental Disorders, 43*(1), 34-44. doi:10.1007/s10803-0121544-6

Laver, K., Ratcliffe, J., Geroge, S., Burgess, L., & Crotty, M. (2011). Is the Nintendo Wii fit really acceptable to older people?: A discrete choice experiment. *BioMed Central Geriatrics, 11*(64), 1-6. doi: 10.1186/1471-2318-11-64

Levac, D. E., & Miller, P. A. (2013). Integrating virtual reality video games into practice: Clinicians' experiences. *Physiotherapy Theory & Practice, 29*(7), 504-512. doi:10.3109/09593985.2012.762078

Lieberman, D., & Scheer, J. (2002). AOTA's evidence-based literature review project: An overview. *American Journal of Occupational Therapy, 56*(2), 344-249. doi:10.5014/ajot.56.3.344

Lloréns, R., Gil-Gómez, J., Alcañiz, M., Colomer, C., & Noé, E. (2015). Improvement in balance using a virtual reality-based stepping exercise: a randomized controlled trial involving individuals with chronic stroke. *Clinical Rehabilitation, 29*(3), 261-268. doi:10.1177/0269215514543333

Luna-Oliva, L., Ortiz-Gutiérrez, R. M., Cano-de la Cuerda, R., Piédrola, R. M., AlguacilDiego, I. M., Sánchez-Camarero, C., & Martínez Culebras, M. C. (2013). Kinect Xbox 360 as a therapeutic modality for children with cerebral palsy in a school environment: A preliminary study. *Neurorehabilitation, 33*(4), 513-521. doi:10.3233/NRE-131001

Nam-Yong, L., Dong-Kyu, L., & Hyun-Seung, S. (2015). Effect of virtual reality dance exercise on the balance, activities of daily living, and depressive disorder status of Parkinson's disease patients. *Journal of Physical Therapy Science, 27*(1), 145-147. doi:10.1589/jpts.27.14

Park, J., Lee, S., Ko, D. (2013) The effects of the Nintendo Wii exercise program on chronic work-related low back pain in industrial workers. *Journal of Physical Therapy Science, 25*(8), 985-988. doi:10.1589/jpts.25.985

Plow, M. & Finlayson, M. (2014). A qualitative study exploring the usability of the Nintendo Wii Fit among persons with multiple sclerosis. *Occupational Therapy International, 21*(1), 21-32. doi: 10.1002/oti.1345

Proffitt, R., & Lange, B. (2015). Considerations in the efficacy and effectiveness of virtual reality interventions for stroke rehabilitation: Moving the field forward. *Physical Therapy, 95*(3), 441-448. doi:10.2522/ptj.20130571

Salem, Y., Gropack, S., Coffin, D., and Godwin, E. (2012). Effectiveness of a low-cost virtual reality system for children with developmental delay: a preliminary randomized single-blind controlled trial. *Physiotherapy 98*(3), 189-195. doi: http://dx.doi.org/10.1016/j.physio.2012.06.003

Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., Thorpe, K., Cohen, L., & Bayley, M. (2010). Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation. *Stroke 41*(7), 1477-84. doi: 10.1161/STROKEAHA.110.584979

Sparkes-Griffin, C. (2013, February 9). Wii-habilitation: Using the Wii as an effective intervention tool for seniors. *OT Practice, 18*(3), 18-19.

Trombly, C. A., Tickle-Degnen, L., Baker, N., Murphy, S., & Ma, H. (1999). *Levels of evidence for occupational therapy outcomes research*. Unpublished table, Boston University.

Virtual Reality Society. (2015). Virtual reality. Retrieved from http://www.vrs.org.uk/

Williams, B., Doherty, N., Bender, A., Mattox, H., & Tibbs, J. (2011). The effect of Nintendo Wii on balance: A pilot study supporting the use of the Wii in occupational therapy for the well elderly. *Occupational Therapy in Health Care, 25*(2-3), 131-139. doi: 10.3109/07380577.2011.560627

Yamkovenko, S. (May 18, 2015). *Helping practitioners with productivity requirements: AOTA collaborates with facility organizations.* Retrieved from http://www.aota.org/practice/ethics/advisory.aspx

Yip, B. C., & Man, D. W. (2013). Virtual reality-based prospective memory training program for people with acquired brain injury. *Neurorehabilitation, 32*(1), 103-115. doi:10.3233/NRE-130827

APPENDICES

APPENDIX A

PRODUCT

Virtual Reality: An Evidence-Based Guide for Occupational Therapy

Grant Mitchell, MOTS

Kyle Nelson, MOTS

Sclinda Janssen, PhD, OTR/L

Table of Contents

Introduction

Advances in virtual reality (VR) technology have had significant progress in the last decade. With increased access to this technology, VR is becoming integrated into society and the daily lives of clients. Researchers have reported a variety of benefits and barriers in recent studies with the use of VR in the clinical setting. Benefits include: client motivation, increased safety during activity, and increased engagement in lost occupations (Levac & Miller, 2013; Proffitt & Lange, 2015). Though VR is becoming more frequently integrated into occupational therapy (OT) practice with much supporting evidence on efficacy, the primary barrier to the practical use of VR is related to the novelty of the technology and practitioner familiarity with the operation and evidence-based use of VR. (Levac & Miller, 2013; Proffitt & Lange, 2015). A primary barrier to using evidence-based VR is the lack of an organizational resource to guide practical application of VR to therapeutic interventions.

Benefits of using VR

- Increased motivation
- Increased safety during activity
- Engagement in lost occupations

The authors of this guide completed an extensive literature review of five databases regarding the use of VR. The authors located information related to using two of the most common VR systems found in the literature, the Nintendo Wii and Xbox Kinect. The data was synthesized and organized into charts to create an evidence-based resource guide for practitioner's adaptation and/or modification of VR activities. By organizing it according to the *Occupational Therapy Practice Framework: Domain and Process 3rd edition* (OTPF-3; AOTA, 2014), practitioners will be supported in addressing their specific client needs. The remainder of this chapter describes the organization of the resource guide.

Guide Organization

The authors of this product intend to provide a tool for practitioners to help them filter through the large pool of studies and locate current and relevant research supporting the use of VR in practice. This will assist practitioners in making effective evidence-based choices in their use of VR. The authors of this guide organized the evidence found from the literature into sections according to aspects in the domain of the OTPF-3 (AOTA, 2014), which includes: *Occupations, Client Factors, Performance Skills, Performance Patterns*, and *Context and Environment*. An additional section of *Assessment Tools* was created as described below. Each of these six sections contains an introduction and evidence table. A description of how to utilize the evidence tables is addressed under the *Navigating the Charts* header later in this section. These six sections are also enhanced by the seventh section, *Case Scenarios*, which presents potential uses for each of the previous tables. The following sections are addressed within the evidence-based guide:

- **Occupations:** Occupations consist of activities of daily living, instrumental activities of daily living, rest and sleep, education, work, play, leisure, and social participation (AOTA, 2014). This aspect had fewer results compared to client factors and performance skills, and was concentrated in the social participation aspect. As occupation is central to OT, there is a significant need for research regarding VR in relation to occupation considering the current lack of literature.

Chart sections

1. **Occupations**
2. Client Factors
3. Performance Skills
4. Performance Patterns
5. Context & Environment
6. Assessment Tools
7. Case Scenarios

- **Client Factors:** Client factors consist of vales, beliefs, spirituality, body functions, and body structures (AOTA, 2014). This aspect included the largest body of literature of found by the authors of this guide, with some of the categories and sub-categories including several articles. Though research would benefit all aspects, this section requires the least future research and due to the array of examples given in literature.

Chart sections

1. Occupations
2. **Client Factors**
3. **Performance Skills**
4. **Performance Patterns**
5. Context & Environment
6. Assessment Tools
7. Case Scenarios

- **Performance Skills:** Performance skills are the building blocks or units of action that combine to organize how individuals participate in occupation (AOTA, 2014). This aspect included a significant amount of literature. This section is especially useful to the practitioner due to the generalizability of the aspect. Practitioners must use clinical judgment to utilize VR to address same or similar performance factors in different populations and scenarios. However, there remains a need to perform more research related to performance factors of mental function.

- **Performances Patterns:** Performance patterns consist of habits, routines, roles, and rituals (AOTA, 2014). The primary theme demonstrated in this section is the use of VR in relation to social interactions. Areas for new research includes the changes that might occur with VR and performance patterns, and the need for literature describing the other areas of performance patterns influenced by VR.

- **Context and Environment:** Context consists of the cultural, personal, temporal, and virtual aspects, and environment consists of physical and social aspects (AOTA, 2014). Due to virtual reality being considered a context, all articles found could be included in this section. However, the authors of this guide organized and displayed the evidence that explicitly addressed the effect the VR context or environment had on outcomes.

- **Assessment Tools:** As assessment tools are not an aspect categorized within the OTPF-3 (AOTA, 2014) and may include a variety of the above listed categories, assessment tools have been listed within their own section. Assessment tools included in this section are frequently used as outcome measures for determining overall progress in therapy or progress in a variety of areas that are often affected by a particular diagnosis, such as the Fugle-Meyer Assessment assessing motor function, balance, sensation, and joint function. Further organization of the Assessment Tools section of the evidence-based guide can be found in the introduction to the section.

Chart sections

1. Occupations
2. Client Factors
3. Performance Skills
4. Performance Patterns
5. **Context & Environment**
6. **Assessment Tools**
7. **Case Scenarios**

- **Case Scenarios:** Case Scenarios include examples of various ways OT practitioners may implement each of the preceding sections. Each case scenario presents a situation, the use of a theoretical framework to guide intervention, a description of the intervention process, and the results of intervention.

Navigating the Charts

Sections to this guide are organized according to the OTPF-3 (AOTA, 2014). Each section contains a chart of research pertaining to that aspect. The chart headers (see Figure 1) include the following:

(Aspect)	**Use of Virtual Technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(Category)						

Figure 1. Chart Section Headers

- **Aspect:** This lists the area within the domain of the OTPF-3 (AOTA, 2014) being discussed including; occupations, client factors, performance patterns, performance skills, context and environment, or assessment tools (not listed in the OTPF-3). The aspect is displayed in italics, such as *Occupations*. All labels underneath the aspect display the category or when applicable, subcategory to that aspect. For example, muscle functions is the category, while endurance is the subcategory found within the OTPF-3. When multiple research articles address the same category, the articles are listed in order of level of evidence.

- **Use of Virtual Technology:** This lists which technology is being utilized in the literature. The Nintendo Wii and Xbox Kinect are the primary consoles representing VR technology addressed with the exception of a few research articles that utilize one of the afore-mentioned technologies with or in comparison to another such as the Sony EyeToy. Within the Use of Virtual Technology section, the main VR system is bolded (i.e. **Nintendo Wii, Xbox Kinect**), the disk/game pack is italicized (i.e. *Wii Sports, Kinect Adventures, etc.*), and the individual game is in normal font (i.e. Tennis, Baseball, etc.).

<table>
<tr><th>(Aspect)</th><th>Use of Virtual Technologies</th><th>Author, year</th><th>Population</th><th>Groups</th><th>Assertions/Outcomes</th><th>Level of evidence</th></tr>
<tr><td colspan="7">(Category)</td></tr>
</table>

Figure 1. Chart Section Headers

- **Author/Year:** This lists the author and year for referencing purposes. For further information regarding any article listed, please review the corresponding article, which can be found in the references section.

- **Population:** This lists the population or condition utilized in the research reported. Examples include stroke or community-dwelling older adults. When the research included notable additional inclusion criteria, such as cerebral palsy and pediatric, this was listed following the primary condition in the following format: Cerebral Palsy, Pediatric.

- **Comparison to:** This lists the number of groups and what experimental conditions they were exposed to as stated in the research design. All articles utilized in this product included either a case study, single subject, or group using VR. The group and number is listed in the following format “G1, G2, G3…” Conditions groups were exposed to follow the group number and may include traditional therapy, no therapy, different frequencies of therapy, and more.

(Aspect)	**Use of Virtual Technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(Category)						

Figure 1. Chart Section Headers

- **Assertions/Outcomes:** This lists a condensed and short summary of the relevant outcomes and evidence found in the literature with a primary focus on whether the use of VR resulted in significant improvement, similar improvement to another condition, or a lack of improvement.

- **Level of Evidence:** This lists the strength of the evidence using the terms low, medium, high, or anecdotals. These terms organize the level of evidence the authors of this guide categorized by the model adapted from Sackett, Rosenberg, Gray, Haynes, and Richardson (1996). *Low* incudes single-subject design, narratives, and case studies. *Medium* includes non-randomized control trials single group/treatment and non-randomized control trials with two groups but a sample size less than 20 per condition. *High* includes non-randomized control trials with two groups and a sample size greater than 20 per condition and randomized control trial studies.

- **Category:** According to each aspect of the OTPF-3 (AOTA, 2014), the aspects consist of categories and subcategories. To organize the chart, subcategories such as in the example of occupation, which could include brushing teeth, showering, and dressing, would be listed under it’s corresponding category of activities of daily living (ADLs).

An important distinction in the literature collected when understanding the outcome data is recognizing what the experimental VR group was compared to. For example, when no significant difference was found between the experimental VR group and traditional therapy, this only indicates the VR was not superior to traditional therapy and does not mean it was ineffective. Therefore, the use of VR may still benefit the client equally as well as traditional therapy and can be an effective tool when matched appropriately to the client and situation. When no significant difference was found between the experimental VR group and a control group receiving no therapy, this would indicate that VR is not supported, as VR demonstrated the same benefits as no therapy at all. When notable, the authors of this guide indicate when results were not significant but did conclude a positive correlation or secondary effects.

Keywords and Definitions

A list of keywords and definitions has been included to assist with the understanding of the information and devices used and described throughout this guide. These keywords and definitions include not only clinically used words, but also common and technological words relevant to the topic of VR. This is to establish and understanding of the technology and information not explicitly discussed in the clinical literature regarding VR, though it is influenced by concepts such as user emersion. User emersion, for example, relates to the level of engagement by the VR participant's sensory system. This engagement of the sensory system within the VR context can be important to the practitioner when considering whether VR would be a good fit to the client's needs. Emersion as well as other keywords and definitions are listed below:

- **Augmented Reality:** Computer-generated images over-laid on top of real world objects. These images are still viewed through a lens or screen in which the participant can view both the computer image and the natural environment. While the Nintendo Wii is exclusively virtual reality and not augmented reality, the Xbox Kinect could be considered either AR or VR dependent upon the game. For the purpose of this guide, all technology will be referred to as VR.

- **Console:** A computer system designed specifically for game applications. The hardware or computer components, such as the graphics, are designed to support gameplay with speed and color rather than versatility and range of computer applications.

- **Controller/Remote:** A hand-held device (Figure 2) used to control the game. This is a device used to interact with the VR environment similar to a computer mouse, but designed to support game play.

Figure 2. Nintendo Wii Controller

- **Emersion:** The degree to which a participant's sensory system is engaged in the VR environment. A television viewed at a distance with the sound off is an example of a low level of emersion. VR goggles covering the users entire field of view with sound and a vibrating controller is an example of a high level of emersion.

- **Gesture Control:** The use of physical movement such as the hands or head to control the VR environment, often in place of a controller or remote.

- **Hand-Held Device:** Mobile electronic devices including cell phones and touch screen notebooks and tablets. The iPad is another common use of VR and the distinction of these technologies is constantly changing.

- **Interface:** The type of control used to interact with the VR environment. This may include a touchscreen television, remote control, or gesture control viewed on the television screen.

Figure 3. Xbox Kinect Sensor

- **Kinect:** A sensor (Figure 3) that is an accessory utilized by the Xbox console replacing the need for hand-held controls for movement (gesture) based control.

- **Virtual Reality (VR):** Images that are fully computer generated and displayed on a screen to which a participant can view.

- **Wii:** A game console currently owned by Nintendo that specifically uses hand-held controls and other accessories with built in sensors to detect movement. The movement is translated to the television screen where the participant can view their interaction with the VR environment. (Figure 4)

- **Xbox:** A game console currently owned by Windows that can utilize the Kinect accessory for Xbox specific games. (Figure 5)

Figure 4. Nintendo Wii Console

Figure 5. Xbox Console

Society and technology can change at a fast pace making it difficult for practitioners to maintain a current understanding of the cultural trends and the skills and competency held by their profession. However, it is especially important for OT practitioners to have a strong understanding of current cultural trends to have an effective evidence-based and holistic approach when interacting with clients. This is reflected through the inclusion of the virtual context within the OTPF-3 as an environment treatment may take place in (AOTA, 2014). The authors of this guide have generated and organized current literature to promote understanding of current evidence regarding the use of VR in practice. This section of the guide includes an introduction, information regarding how to use the charts, and key words and definitions that will support the ease of navigating and understanding of the information presented.

SECTION 1: OCCUPATIONS

As the technology surrounding VR evolves and changes, it is being increasingly incorporated and integrated into day-to-day activity. VR can include the use of smartphones and computers, common tools utilized in work and educational environments. Even though literature can be found regarding VR in the workplace, educational settings, and daily life, the authors of this guide found limited research regarding VR as it relates to occupation from a rehabilitation perspective.

Despite the limited research of VR in relation to occupation, this section includes the evidence found by the authors of this guide that does exist regarding VR as it relates to promoting positive outcomes in the areas of occupations found within the OTPF-3 (AOTA, 2014). Occupation is an all-encompassing term to describe activities and tasks that people engage in on a day-to-day basis (AOTA, 2014). While OT intervention is occupation focused, treatment can occur through a variety of approaches and settings. VR relates to occupation as a context through which intervention takes place. The evidence selected for this section can be used to identify overarching uses of VR as a modality to address occupation in the clinical setting.

Table 1: Evidence-Based use of Virtual Reality: Occupations

Occupations	Use of Virtual Technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Activities of Daily Living (ADL's)						
ADLs	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz et al., 2013	Parkinson's Disease	G1: VR intervention	There was significant improvement in ADL function following intervention. These results remained significant during a follow-up 1 month later	Medium
ADL Related Movement	**Xbox Kinect:** Rally Ball, 20,000 Leaks	Parry et al., 2014	Normal Children for Burn Patient Application	G1: VR intervention	The demands of the VR intervention including range of motion and endurance were comparable to demands for completing ADLs.	Low
ADLs	**Nintendo Wii:** *Wii Sports*	Winkels, Kottink, Temmink, Nijlant, & Buurke, 2013	Cerebral Palsy, Children	G1: VR intervention	There was a significant improvement in performing ADLs. Participants also reported high levels of enjoyment.	Medium
Feeding	**Xbox Kinect:** *Sports I*, Joy Ride, *Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There was a significant positive outcome in feeding between pretest and posttest results following the use of the Wii as an intervention strategy.	Medium
Instrumental Activities of Daily Living (IADL's)						
Community Mobility	**Nintendo Wii:** *Wii Fit*	Williams, et al., 2011	Well-Elderly	G1: VR intervention	A participant stated that prior to use of the Wii, he was unable to ambulate in the community without a wheelchair.	Anecdotal

Occupations	Use of Virtual Technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Exercise	**Nintendo Wii:** *Wii Fit*	Forsberg, Nilsaga, & Boström, 2015	Multiple Sclerosis	G1: VR intervention	Many of the participants identified the Wii as a good potential form of exercise and activity.	Anecdotal
Leisure						
Engage-ment	**Nintendo Wii:** *Wii Sports*	Celinder & Peoples, 2012	Stroke	G1: VR intervention	The participants enjoyed engaging in occupations, such as bowling and fishing, with the Wii. The Wii connected the participants to their previous engagement in the real-world version of similar activities.	Low
Social Participation						
Social Interaction	**Nintendo Wii:** *Wii Fit*	Forsberg, Nilsaga, & Boström, 2015	Multiple Sclerosis	G1: VR intervention	The participants identified that the Wii could be used as a social activity to interact with family or friends.	Anecdotal
Social Participa-tion	**Nintendo Wii:** *Wii Sports:* Baseball, Boxing, Golf, Tennis, 10-pin Bowling	Keogh, Power, Wooller, Lucas, Whatman, 2014	Elderly, Residential Aged-Care Center	G1: VR intervention G2: No intervention	The individuals within VR intervention group found that the Wii increased social participation and enjoyment when spending time with others.	Anecdotal
Social Participa-tion	**Nintendo Wii:** *Guitar Hero, Wii Sports*: Bowling	Janssen, Verschuren, Levac, Eemers, & Ketelaar, 2012	TBI, Adolescent	G1: VR intervention	Participants were motivated to participate and interact with other peers per self-Report	Low

SECTION 2: CLIENT FACTORS

In the OTPF-3, client factors are a comprehensive list of person elements including specific capacities, characteristics, physical abilities, cognitive abilities, and beliefs (AOTA, 2014). The authors of this guide categorized the greatest amount of literature according to the client factors section. Client factors may be a larger aspect due to the feasibility of measuring client factors in research outcomes such as heart rate, strength, and range of motion. This aspect included a significant amount of literature pertaining to physical therapy due to the more biomechanical categories such as balance, the most commonly addressed client factor and researched category overall. Practitioners will be able to explore the client factors supported by the evidence, and use their clinical reasoning to apply the same activity principles to their clients.

Table 2: Evidence-Based use of Virtual Technologies: Client Factors

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Body Functions						
General Health	**Xbox Kinect:** Zen Energy	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	Both the VR and group-based exercise groups demonstrated a significant improvement in general health as measured by the Health-Related Quality of Life.	High
General Health	**Nintendo Wii:** Wakeboard, Frisbee dog, Jet ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention G2: Stability exercise	There was a significant increase in general health in both groups as measured by RAND-36.	High
Body Functions: Mental Functions						
Cognitive Exertion	**Nintendo Wii:** *Wii Fit*	Celinder & Peoples, 2012	Stroke	G1: VR intervention	Individuals stated that they felt exhausted cognitively following the use of the Nintendo Wii.	Low
Depression	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention G2: Health education sessions	The authors stated that multiple participants described having more social support, engagement, enjoyment, and a sense of accomplishment, which may have led to a decrease in depressive symptoms.	Anecdotal
Motivation	**Nintendo Wii:** *Wii Fit, Wii Sports*	Bacon, Farnworth, & Boyd, 2012	Obesity, at risk, forensic mental health	G1: VR intervention	Both participants found the Wii to be an engaging form of exercise.	Low
Motivation	**Nintendo Wii:** *Wii Sports*:	Celinder & Peoples, 2012	Stroke	G1: VR intervention	The use of the Nintendo Wii activities was found to increase an individual's motivation to participate in rehabilitation.	Low

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Anxiety	**Nintendo Wii:** *Wii Fit, Wii Sports*	Yohanna et al., 2011	Stroke	G1: VR intervention G2: Standard therapy	There was no significant difference in anxiety level between the groups, but there was greater improvement within the Wii group than the standard therapy group.	Medium
Attention and Activity	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The Wii group demonstrated significantly greater results in attention and activity (subtest of Test of Sensory Integration Function) than the standard OT group and the control group.	High
Endurance	**Xbox Kinect:** *Adventures:* Space Pop, 20,000 Leaks, Reflex Ridge, River Rush	Pompeu et al., 2014	Parkinson's Disease	G1: VR intervention	There were no significant improvements in body function and endurance following the VR intervention.	Low
Emotion	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of Emotion as measured by the Parkinson’s Disease Questionnaire (39 item) following intervention. These results remained significant when measured at 1-month follow-up.	Medium
Emotional Well-being	**Nintendo Wii:** Wakeboard, Frisbee dog, Jet Ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention G2: Stability exercise	There was a significant increase in the VR group only in relation to emotional well-being as measured by the RAND-36.	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Emotional-Behavioral Reactivity	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The Wii group demonstrated significantly greater results in emotional-behavioral reactivity (subtest of Test of Sensory Integration Function) than the standard OT group and the control group.	High
Energy	**Nintendo Wii:** Wakeboard, Frisbee dog, Jet Ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention G2: Stability exercise	There was a significant increase in the VR group only in relation to energy as measured by the mental health composite of the RAND-36.	High
Fear of Falling	Nintendo Wii: Wii Fit: Table Tilt, Tightrope, Penguin Slide	Prata & Scheider, 2014	Elderly Fallers, Female	G1: VR intervention	There was a significant decrease in fear of falling following the VR intervention.	Medium
Focus	**Nintendo Wii:** Guitar Hero, *Wii Sports:* Bowling	Janssen, Verschuren, Levac, Eemers, & Ketelaar, 2012	TBI; Adolescent	G1: VR intervention	The participant demonstrated an increased ability to focus and remain on task when engaged in VR games per self-report.	Low
Intervention Enjoyment	**Nintendo Wii:** Bowling and Boxing	Chen, et al., 2014	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy and UE exercises G3: Standard therapy and XavixPort Gloves.	The Nintendo Wii and XavixPort group both had significantly greater enjoyment during interventions than in the conventional treatment group.	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Intrinsic Motivation	**Nintendo Wii**	Fan et al., 2014	Stroke	G1: VR intervention G2: Standard therapy G3: Board game G4: No treatment	The Wii group demonstrated a higher level of intrinsic motivation than all other groups. The VR group also demonstrated a significantly higher level of motivation than the board game group.	High
Mental Health	**Xbox Kinect:** Zen Energy	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	The VR group demonstrated a significant improvement in mental health as measured by the Health-Related Quality of Life.	High
Motivation	**Nintendo Wii**: Tilt, Tightrope, Soccer, Balance Bubble	Subramaniam, Hui-Chan, & Bhatt, 2014	Stroke, Commun-ity Dwelling	G1: VR intervention	There was a significant improvement in motivation to participate, indicating increase in adherence to interventions.	High
Body Functions: Sensory Functions						
Balance	**Nintendo Wii:** *Wii Fit*	Forsberg, Nilsaga, & Boström, 2015	Multiple Sclerosis	G1: VR intervention	Participants and therapists both found that the participants' balance increased over time with practiced use of the Wii.	Anecdotal
Balance	**Nintendo Wii:** Wakeboard, Frisbee Dog, Jet Ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention G2: Stability exercise	There was no improvement in balance among individuals with low back pain within the VR group.	High
Balance	**Nintendo Wii:** Tilt, Tightrope, Soccer, Balance Bubble	Subramaniam, Hui-Chan, & Bhatt, 2014	Stroke, Commun-ity Dwelling	G1: VR intervention	Following VR intervention, there was an increase in balance demonstrated by a significant improvement in reaction time and an increase in movement speed.	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Balance	**Xbox Kinect:** Rally Ball, Reflex Ridge, River Rush, 20,000 Leaks	Vernadakis, Derri, Tsitskari, & Antoniou, 2014	Ankle injury, Male Athletes	G1: VR intervention G2: Traditional physiotherapy intervention G3: No intervention	The VR and physiotherapy groups both demonstrated a significant increase in balance in comparison to the control group.	High
Balance	**Nintendo Wii**	Tatla, Radomski, Cheung, Maron, & Jarus, 2014	Traumatic Brain Injury, Children	G1: VR intervention	All four participants demonstrated an increase in balance. However, only one participant's improvements were significant.	Low
Balance	**Nintendo Wii:** *Wii Fit*	Williams, Doherty, Bender, Mattox, & Tibbs, 2011	Well-Elderly	G1: VR intervention.	Individuals in the well-elderly population were found to have a significant increase in balance following use of the Nintendo Wii. This included a decrease in individuals that met criterion for needing balance training from 10 individuals prior to intervention, to 1 individual after the intervention.	Medium
Balance	**Nintendo Wii:** *Wii Sports*: Bowling, Boxing, Tennis, **Xbox Kinect:** Your Shape Fitness Evolved, Tai Chi,	Taylor et al., 2012	Older Adults	G1: VR intervention	There was no significant improvement in balance following VR intervention.	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
(Continued)	*Kinect Sports:* Bowling Boxing, Tennis					
Balance	**Nintendo Wii:** *Wii Fit Plus*	Holmes, Gu, Johnson, & Jenkins, 2013	Parkinson's Disease	G1: VR intervention	There were no significant differences in balance following the intervention period; however, balance was improved at mid-intervention prior to reverting back to baseline.	Medium
Balance	**Nintendo Wii:** *Wii Fit*	Owen, Garne, Mark Loftin, Van Blerk, & Ermi, 2011	Children and Adults	G1: VR intervention	There was no significant improvement in balance as measured by composite equilibrium score following home Wii intervention.	Medium
Balance	**Nintendo Wii:** *Wii Fit*	McClanachan, Gesch, Wuthapanich, Flemin, & Kuys, 2013	Acquired Brain Injury	G1: VR intervention in addition to standard therapy G2: Standard therapy alone (Cross-over trial)	There were improvements in balance post-intervention as measured by the Balance Outcome Measure for Elder Rehabilitation for the conventional therapy and Wii intervention groups; however, the improvements were not significant.	High
Balance	**Nintendo Wii**	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, Child	G1: VR intervention	The participant demonstrated an increase in balance as a subtest of the Bruininks-Oseretsky Test of Motor Proficiency (second edition) following VR intervention.	Low
Balance	**Nintendo Wii:** *Wii Fit Plus*	Mombarg, Jelsma, & Hartman, 2013	Poor Motor Performance, Children	G1: VR intervention G2: No intervention	Both the control and experimental groups demonstrated increase in balance as measured by the Bruininks-Oseretsky Test of Motor Proficiency (second edition) and Movement	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
(Continued)					Assessment Battery for Children (second edition); however, only the VR group demonstrated improvements that were significant.	
Balance/Gait	**Xbox Kinect:** *Adventures:* Space Pop, 20,000 Leaks, Reflex Ridge, River Rush	Pompeu et al., 2014	Parkinson's Disease	G1: VR intervention	There were no significant improvements in balance and gait following VR intervention.	Low
Bilateral Integration Sequencing	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significantly greater results in bilateral integration sequencing (subtest of Test of Sensory Integration Function) than the standard OT group and the control group.	High
Bodily Discomfort	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of Bodily Discomfort as measured by the Parkinson's Disease Questionnaire (39 item) following intervention.	Medium
Bodily Pain	**Xbox Kinect:** Zen Energy	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	The VR group demonstrated a significant improvement in bodily pain as measured by the Health-Related Quality of Life.	High
Pain	**Nintendo Wii:** *Wii Fit*	Fung, Ho, Shaffer, Chung, & Gomez, 2012	Total Knee Replace-ment	G1: VR intervention G2: Lower extremity strengthening and balance	There was no significant difference in pain between the groups following intervention.	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Pain	**Nintendo Wii:** Wakeboard, Frisbee Dog, Jet Ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention G2: Stability exercise	There was a significantly decrease in pain within the VR group in comparison to the control group.	High
Pain	**Nintendo Wii**	Joo et al., 2010	Stroke	G1: VR intervention	There was no significant improvement in pain following intervention.	Medium
Pain	**Nintendo Wii:** *Wii Fit, Wii Sports*	Yohanna et al., 2011	Stroke	G1: VR intervention G2: Standard therapy	Both groups demonstrated an improvement in pain that was not significant; however, the VR group demonstrated a greater improvement in pain than the standard therapy group.	Medium
Pain	**Nintendo Wii:** *Wii Fit*	Williams, Doherty, Bender, Mattox, & Tibbs, 2011	Well-Elderly	G1: VR intervention	Two individuals stated a decrease in pain following the VR intervention.	Anecdotal
Posture	**Xbox Kinect:** *Sports*: Joy Ride, *Adventures*	Gutiérrez et al., 2013	Multiple Sclerosis	G1: VR intervention G2: Standard physiotherapy	There was a significant improvement in posture within both groups. The improvements in balance were related to vestibular and visual use, preference of sensory inputs, and improved automatic postural response.	High
Sensory Discrimination	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Children with Down syndrome	G1: VR intervention G2: Standard therapy G3: No intervention	Both the VR and standard OT groups demonstrated a significant increase in sensory discrimination as a subtest of the Test of Sensory Integration Function; however, there was no significant difference between the VR and standard OT groups.	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Sensory Modulation	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Children with Down syndrome	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significantly greater results in sensory modulation (subtest of Test of Sensory Integration Function) than the standard OT group and the control group.	High
Sensory Searching	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Children with Down syndrome	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significantly greater results in sensory searching (subtest of Test of Sensory Integration Function) than the standard OT group and the control group.	High
Body Functions: Neuromusculoskeletal and Movement-related Functions						
Active Range of Motion (AROM)	**Xbox Kinect:** Rally Ball, 20,000 Leaks	Parry, et al., 2014	Normal Children for Burn Patient application	G1: VR intervention	The Xbox Kinect intervention resulted in greater AROM for shoulder flexion, shoulder abduction, and elbow flexion than the Play Station Move.	Low
Active Range of Motion (AROM)	**Nintendo Wii:** *Wii Fit, Wii Sports*	Yohanna et al., 2011	Stroke	G1: VR intervention G2: Standard therapy	The VR group demonstrated greater improvement in AROM than the standard therapy group; however, the difference between the groups was not significant.	Medium
Active Range of Motion (AROM) (Elbow)	**Xbox Kinect:** *Sports, Adventure*	Sin & Lee, 2013	Stroke	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	Both groups demonstrated significant improvements in AROM for elbow flexion. The VR group demonstrated a significantly greater improvement than the standard therapy alone group.	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Active Range of Motion (AROM) (Shoulder)	**Xbox Kinect:** *Sports, Adventure*	Sin & Lee, 2013	Stroke	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	Both groups demonstrated significant improvements in AROM for shoulder flexion, extension, and abduction. The VR group demonstrated a significantly greater improvement than the standard therapy alone group.	High
Active Range of Motion (AROM) (Wrist)	**Xbox Kinect:** *Sports, Adventure*	Sin & Lee, 2013	Stroke	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	Both groups demonstrated significant improvements in AROM for wrist extension. There was no significant difference between the groups.	High
Elbow Extension	**Xbox Kinect:** *Sports:* Boxing, Bowling, *Adventure*: Rally Ball, 20,000 Leaks, Space Pop	Lee, 2013	Stroke, Chronic	G1: VR intervention and standard therapy G2: Standard therapy alone	The VR group demonstrated significant improvements in elbow extension strength following intervention; however, the improvements were not significantly greater than the standard therapy alone group.	High
Elbow Flexion	**Xbox Kinect:** *Sports:* Boxing, Bowling, *Adventure*: Rally Ball, 20,000 Leaks, Space Pop	Lee, 2013	Stroke, Chronic	G1: VR intervention and standard therapy G2: standard therapy alone	The VR group demonstrated significant improvements in elbow flexion strength following intervention; however, the improvements were not significantly greater than the standard therapy alone group.	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Flexibility	**Nintendo Wii:** *Wii Fit*	Owen, Garne, Mark Loftin, Van Blerk, & Ermi, 2011	Children and adults	G1: VR intervention	There was no significant improvement in flexibility as measured by the Sit-and-Reach Test following home-based VR intervention.	Medium
Knee Extension	**Nintendo Wii:** *Wii Fit*	Fung, Ho, Shaffer, Chung, & Gomez, 2012	Total Knee Replacement	G1: VR intervention G2: Lower extremity strengthening and balance	There was no significant difference between the two groups in relation to knee extension following the intervention period.	High
Knee Flexion	**Nintendo Wii:** *Wii Fit*	Fung, Ho, Shaffer, Chung, & Gomez, 2012	Total Knee Replacement	G1: VR intervention G2: Lower extremity strengthening and balance	There was no significant difference between the two groups in relation to knee flexion following the intervention period.	High
Range of Motion, Upper Extremity	**Nintendo Wii:** *Wii Sports*	Shiner, Byblow, & McNulty, 2014	Stroke	G1: VR intervention with priming G2: VR intervention alone	The VR with priming group demonstrated a significantly greater improvement in upper extremity range of motion than the VR without priming group.	Medium
Range of Motion	**Nintendo Wii:** Bowling and Boxing	Chen et al., 2014	Stroke	G1: Standard therapy and VR intervention. G2: Standard therapy and UE exercises. G3: standard	All three groups demonstrated a significant increase in range of motion following the intervention period.	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
(Continued)				therapy and XavixPort Gloved.		
Shoulder Extension	**Xbox Kinect:** *Sports:* Boxing, Bowling, *Adventure:* Rally Ball, 20,000 Leaks, Space Pop	Lee, 2013	Stroke, Chronic	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	There were significant improvements in shoulder extension strength following intervention in the VR group. There were no significant differences between the VR group and the standard therapy alone group.	High
Shoulder Flexion	**Xbox Kinect:** *Sports:* Boxing, Bowling, *Adventure:* Rally Ball, 20,000 Leaks, Space Pop	Lee, 2013	Stroke, Chronic	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	There were significant improvements in shoulder flexion strength following intervention in the VR group. There were no significant differences between the VR group and standard therapy alone group.	High
Wrist Extension	**Xbox Kinect:** *Sports:* Boxing, Bowling, *Adventure:* Rally Ball, 20,000 Leaks, Space Pop	Lee, 2013	Stroke, Chronic	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	There were no significant improvements in wrist extension strength following intervention in the VR group. There were no significant differences between the VR group and standard therapy alone group.	High
Wrist Flexion	**Xbox Kinect:** *Sports:* Boxing, Bowling, *Adventure:*	Lee, 2013	Stroke, Chronic	G1: VR intervention in addition to standard	There were no significant improvements in wrist flexion strength following intervention in the VR group. There were no significant differences	High

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
(Continued)	Rally Ball, 20,000 Leaks, Space Pop			therapy G2: Standard therapy alone	between the VR group and standard therapy alone group.	
Body Functions: Muscle Functions						
Back Strength	**Nintendo Wii:** Wakeboard, Frisbee Dog, Jet Ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention. G2: Stability exercise	There was a significant increase in back strength in both groups with no significant difference between the groups.	High
Endurance	**Nintendo Wii:** Wakeboard, Frisbee Dog, Jet Ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain	G1: VR intervention. G2: Stability exercise	The VR intervention resulted in a significant improvement in energy and fatigue among individuals with low back pain.	High
Grip Strength	**Nintendo Wii:** *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	Children with developmental delay demonstrated a significant improvement in strength following the VR intervention.	High
Grip Strength	**Nintendo Wii:** *Wii Sports Resort:* Swordplay, Table Tennis, Canoe	Choi et al., 2014	Stroke, Sub-acute	G1: standard therapy and VR intervention. G2: standard therapy.	There was no significant difference in grip strength in the VR group. The standard therapy group demonstrated significant improvements in grip strength.	High
Grip Strength	**Nintendo Wii:** *Wii Fit:* Table Tilt, Tightrope, Penguin Slide	Prata & Scheider, 2014	Elderly Fallers, Female	G1: VR intervention	There was no significant improvement in grip strength following the VR intervention.	Medium
Muscular Fitness	**Nintendo Wii:** *Wii Fit*	Owen, Garne, Mark Loftin, Van Blerk, & Ermi, 2011	Children and Adults	G1: VR intervention	There was no significant improvement in muscular fitness as measured by pushups following home-based VR intervention.	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Muscle Contractions, Time-to-Peak (TTP)	**Nintendo Wii**	Fan, et al., 2014	Stroke	G1: VR intervention G2: Standard therapy G3: Board game G4: No treatment	There were significant improvements in TTP immediately after treatment for the biceps brachii and flexor carpi radialis muscles within the VR group only.	High
Strength	**Nintendo Wii**	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, Child	G1: VR intervention	There was no difference in the individual's strength (subtest of Bruininks-Oseretsky Test of Motor Proficiency [second edition]) following the VR intervention.	Low
Upper Extremity Strength	**Nintendo Wii:** *Wii Fit, Wii Sports* (Balance Board games)	Yohanna et al., 2011	Stroke	G1: VR intervention G2: Standard therapy	There was a significant improvement in upper extremity strength from baseline as a result of the intervention.	Medium
Upper Extremity Strength (isometric)	**Nintendo Wii:** *Wii Fit*	Ferguson, Jelsma, Jelsma, & Smits-Englesman, 2013	Developmental Coordination Disorder, Children	G1: VR activities G2: Neuromotor Task Training	Upper extremity strength did not change for either the NTT group or the VR group following intervention.	Medium
Body Functions: Movement Functions						
Bilateral Coordination	**Nintendo Wii**	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, child	G1: VR intervention	The individual's bilateral coordination score (subtest of Bruininks-Oseretsky Test of Motor Proficiency [second edition]) decreased following the Wii intervention.	Low

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Manual Dexterity (Subtest of BOT-2)	**Nintendo Wii**	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, Child	G1: VR intervention	The individual demonstrated an increase in manual dexterity as a subtest of Bruininks-Oseretsky Test of Motor Proficiency (second edition) following intervention with the Wii.	Low
Manual Dexterity	**Nintendo Wii:** *Wii Fit*	AlSaif & Alsenany, 2015	Cerebral Palsy, Children	G1: VR intervention G2: No intervention	Manual Dexterity (Subtest of the Movement Assessment Battery for Children [second edition]) significantly increased within the VR group only.	High
Mobility	**Nintendo Wii:** *Wii Fit:* Table Tilt, Tightrope, Penguin Slide	Prata & Scheider, 2014	Elderly Fallers, Female	G1: VR intervention	There was a significant increase in mobility following the VR intervention.	Medium
Mobility	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz et al., 2013	Parkinson's Disease	G1: VR intervention	There was no significant change in mobility as measured by the Parkinson’s Disease Questionnaire (39 item) following intervention; however, there was a significant improvement in the results at 1 month follow-up.	Medium
Running Speed and Agility	**Nintendo Wii**	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, Child	G1: VR intervention	The individual demonstrated an increase in running speed and agility as a subtest of the Bruininks-Oseretsky Test of Motor Proficiency (second edition) following the VR intervention.	Low
Sway Speed	**Nintendo Wii:** *Wii Fit*	Park, Kim, & Lee, 2015	Elderly	G1: VR intervention G2: Ball exercise	Following the intervention, both groups demonstrated a significant decrease in sway speed. However, the VR group demonstrated greater improvements than the ball exercise.	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Tremor	**Nintendo Wii**: Tennis, Bowling, Boxing	Herz et al., 2013	Parkinson's Disease	G1: VR intervention	The presence of a tremor did not appear to interfere with the performance of the Wii games likely due to the movement required by the game.	Anecdotal
Upper Extremity Movement	**Nintendo Wii:** Cooking Mamma, *Wii Sports*	Saposnik et al., 2010.	Stroke	G1: VR intervention in addition to standard intervention G2: Recreation therapy in addition to standard therapy	The results indicate a significant improvement in UE movement with no adverse events. VR was found to be "safe, feasible, and potentially effective alternative to facilitate rehabilitation" of the upper extremity.	High
Upper Extremity Movement	**Xbox Kinect:** Bowling	Rand, Givon, Weingarden, Nota, & Zeilig, 2014	Stroke	G1: VR intervention G2: Standard therapy	There was significantly higher intensity and increased repetition of upper extremity movements found in VR group in comparison to the standard therapy group.	High
Upper Extremity Movement	**Nintendo Wii:** *Wii Sports*	Shiner, Byblow, & McNulty, 2014	Stroke	G1: VR intervention with priming G2: VR intervention alone	The effect of priming or facilitating bilateral movement prior to beginning activities had a positive improvement in upper extremity movement compared to VR intervention alone.	Medium
Body Functions: Cardiovascular, hematological, immunological, and respiratory system functions						
Energy Expenditure	**Nintendo Wii:** *Wii Sports:* Bowling, Tennis, Dance	Rowland & Rimmer, 2012	Non-ambulatory Young Adults,	G1: VR intervention	The VR intervention resulted in significant energy expenditure used to address endurance. The VR activity of Wii bowling had a greater amount of	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
(Continued)	Dance Revolution		Disabilities		energy expenditure. The researchers recommended adding Velcro weights to further increase the amount of energy used during VR activity.	
Energy Expenditure	**Xbox Kinect:** Just Dance 4	Roopchand-Martin, Nelson, Gordon, & Sing, 2015	Sedentary Female University Students	G1: VR intervention	There was significant energy expenditure during VR intervention as measured by oxygen consumption and change from resting heart rate.	Medium
Energy Expenditure	**Nintendo Wii:** *Wii Sports*, *Sports Resort:* Tennis, Golf, Bowling, Sword Fighting, Archery, Boxing, Frisbee, Tennis, Cycling	Wollershein et al., 2010	Older Women	G1: VR intervention	There was no significant improvement in energy expenditure as measured by an accelerometer.	Medium
Exertion	**Xbox Kinect:** *Kinect Sports*, Kinect Joy Ride, Kinect Disneyland Adventures	Luna-Oliva et al. 2013	Cerebral Palsy, Children	G1: VR intervention	The VR intervention caused increased exertion in children with cerebral palsy; however, this was not an aspect studied and measured by the researchers.	Anecdotal
Aerobics Fitness	**Nintendo Wii:** *Wii Fit*	Owen, Garne, Mark Loftin, Van Blerk, & Ermi, 2011	Children and Adults	G1: VR intervention	There was no significant improvement in aerobics fitness as measured by a graded treadmill test following home-based VR intervention.	Medium

Client Factors	Use of Virtual Technologies	Author, year	Populations	Groups	Assertions/Outcomes	Level of evidence
Body Structures						
Body Composition	**Nintendo Wii:** *Wii Fit*	Owen, Garne, Mark Loftin, Van Blerk, & Ermi, 2011	Children and Adults	G1: VR intervention	There was no significant improvement in body composition as measured by body mass index and percentage of body fat following home-based VR intervention.	Medium
Body Weight	**Nintendo Wii:** *Wii Fit*	Yuen, Holthaus, Kamen, Sword, & Breland, 2011	Systemic Lupus Erythematosus, African American Women	G1: VR intervention	There was a significant reduction in weight following the VR intervention.	Medium
Waist Circumference	**Nintendo Wii:** *Wii Fit*	Yuen, Holthaus, Kamen, Sword, & Breland, 2011	Systemic Lupus Erythematosus, African American Women	G1: VR intervention	There was a significant reduction in waist circumference following the VR intervention.	Medium

SECTION 3: PERFORMANCE SKILLS

Performance skills are the specific actions added together to describe what is required of the participant to engage in occupation (AOTA, 2014). This can be practical to address by VR in OT practice due to isolating the components of the activity that benefit the participant. The research evidence listed within this chart may be applicable across many populations. For example, specific actions used with VR to promote upper extremity strengthening of an individual recovering from a spinal surgery may be the same actions used with an individual recovering from stroke. This allows the OT practitioner to be flexible in the use of VR interventions to address the specific needs of their clients.

While performance skills, such as navigating and choosing, may have been a part of the VR activity, they may not have been as prominent of a focus of the research as the ability to coordinate and manipulate was. Therefore, a greater number of inferred performance skills were required of the participants in the literature than was researched and reported. For this reason, practitioners should always use their clinical reasoning to grade the activity to the needs of the client such as reducing the need to choose and sequence by setting up the game or picking a less difficult game.

Table 3: Evidence-Based use of Virtual Technologies: Performance Skills

Performance Skills	Use of Virtual technologies	Author, year	Population	Comparison to	Assertions/Outcomes	Level of evidence
Motor Skills						
Aiming and Catching	**Nintendo Wii:** *Wii Fit*	AlSaif & Alsenany, 2015	Cerebral Palsy, Children	G1: VR intervention G2: No intervention	Aiming and Catching (subtest of the Movement Assessment Battery for Children [second edition]) scores significantly increased in the VR group only.	High
Bicep Curl	**Nintendo Wii**: *Wii Sports:* Baseball, Boxing, Golf, Tennis, 10-pin bowling	Keogh, Power, Wooller, Lucas, Whatman, 2014	Elderly, Residential Aged-Care Center	G1: VR intervention G2: No intervention	The Wii group demonstrated a significant increase in the number of bicep curl repetitions following the intervention period when compared to the control group.	Medium
Dexterity	**Nintendo Wii**: *Wii Fit Plus*	Esposito, et al., 2013	Migrane without Aura (MoA), children	G1: VR intervention (children with MoA) G2: No intervention (typically developing children)	The VR group demonstrated significant improvements in the dexterity aspect of the Movement Assessment Battery for Children (second edition). The no intervention group demonstrated no changes.	High
Exertion	**Nintendo Wii:** *Wii Sports:* Bowling, Tennis, Boxing; *Dance Dance Revolution:* Disney Dance	Howcroft, et al., 2012	Cerebral Palsy, Children	G1: VR intervention.	There was a significant increase in exertion from baseline for all activities. The activities that required lower extremity use (Dance Dance Revolution: Disney Dance Grooves) or high frequency bilateral upper extremity movements (Boxing) had significantly more exertion than those	Medium

Performance Skills	**Use of Virtual technologies**	**Author, year**	**Population**	**Comparison to**	**Assertions/Outcomes**	**Level of evidence**
(Continued)	Grooves				with low frequency movements (Bowling).	
Fine Motor Integration	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The Wii group demonstrated significantly greater results regarding fine motor integration (subtest of the Bruinins-Oseretsky Test of Motor Proficiency [Second Edition]) than the standard OT group and the control group.	High
Fine Motor Precision	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The Wii group demonstrated significantly greater results regarding fine motor precision (subtest of the Bruinins-Oseretsky Test of Motor Proficiency [Second Edition]) than the standard OT group and the control group.	High
Functional Mobility	**Nintendo Wii**	Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008	Cerebral Palsy, Child	G1: VR intervention	Following the VR intervention, Functional Mobility was noted to increase when ambulating with forearm crutches to a distance previously never achieved.	Low
Gait Speed	**Nintendo Wii:** *Wii Fit*	Nicholson, McKean, Lowe, Fawcett, & Burkett, 2015	Elderly	G1: VR intervention G2: No intervention	There were significant improvements in gait speed for the VR group only following the intervention.	Medium
Hand Eye Coordination	**Nintendo Wii**	Shin, Song, & Hwangbo, 2015	Cerebral Palsy, Children	G1: VR intervention G2: Standard neurological physical therapy	There were significant improvements in hand-eye coordination for both groups with no significant difference between the groups.	Low

Performance Skills	**Use of Virtual technologies**	**Author, year**	**Population**	**Comparison to**	**Assertions/Outcomes**	**Level of evidence**
Lifting large Heavy Objects	**Xbox Kinect:** *Kinect Sports I*, *Kinect Joy Ride*, *Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were no significant differences in lifting large heavy objects (as part of the Jebsen Hand Function Test) between pretest and posttest results following the VR intervention.	Medium
Lifting Large Light Objects	**Xbox Kinect:** *Kinect Sports I*, *Kinect Joy Ride*, *Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in lifting large light objects (as part of the Jebsen Hand Function Test) between pretest and posttest results following the VR intervention.	Medium
Page Turning	**Xbox Kinect:** *Kinect Sports I*, *Kinect Joy Ride*, *Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in Page-turning (as part of the Jebsen Hand Function Test) between pretest and posttest results following the use of the Wii as an intervention strategy.	Medium
Picking up Small Common Objects	**Xbox Kinect:** *Kinect Sports I*, *Kinect Joy Ride*, *Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in picking up small common objects (as part of the Jebsen Hand Function Test) between pretest and posttest results following the VR intervention.	Medium
Postural Control	**Nintendo Wii**	Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008	Cerebral Palsy, Child	G1: VR intervention	There were improvements in postural control in relation to: greater loading on the upper extremities with less reliance on the assistive device, a decrease in center-of-pressure sway, and an increase in symmetry of weight distribution.	Low

Performance Skills	Use of Virtual technologies	Author, year	Population	Comparison to	Assertions/Outcomes	Level of evidence
Postural Control	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significantly greater results in postural movement control (subtest of Test of Sensory Integration Function) than the standard OT group and the control group.	High
Running Speed and Agility	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significantly greater results regarding running speed and agility (subtest of Bruininks-Oseretsky Test of Motor Proficiency [Second Edition]) than the standard OT group and the control group.	High
Stacking Checkers	**Xbox Kinect:** *Kinect Sports I*, *Kinect Joy Ride*, *Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in Stacking Checkers (as part of the Jebsen Hand Function Test) between pretest and posttest results following the VR intervention.	Medium
Stand for Periods of Time	**Nintendo Wii:** *Wii Fit*	Forsberg, Nilsaga, & Boström, 2015	Multiple Sclerosis	G1: VR intervention	Many of the participants identified being able to stand for longer periods of time than prior to the VR intervention.	Anecdotal
Step Length	**Nintendo Wii:** *Wii Fit*	Park, Kim, & Lee, 2015	Elderly	G1: VR intervention G2: Ball exercise	Following the intervention, both groups demonstrated a significant decrease in sway length; however, the VR group demonstrated greater improvements than the control group.	Medium

Performance Skills	Use of Virtual technologies	Author, year	Population	Comparison to	Assertions/Outcomes	Level of evidence
Upper Extremity Function	**Nintendo Wii**: *Wii Sports*	Winkels, Kottink, Temmink, Nijlant, & Buurke, 2013	Cerebral Palsy, Children	G1: VR intervention	There was no significant improvement in upper extremity function as measured by the Melbourne Assessment of Upper Limb Function.	Medium
Upper limb Coordination	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The Wii group demonstrated significantly greater results in fine motor upper limb coordination as a subtest of the Bruininks-Oseretsky Test of Motor Proficiency (Second Edition) than the standard OT group and the control group.	High
Upper-Limb Coordination	Nintendo Wii	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, Child	G1: VR intervention	The individual demonstrated an increase in upper-limb coordination as a subtest of the Bruininks-Oseretsky Test of Motor Proficiency (second edition) following the VR intervention.	Low
Walking	Nintendo Wii Fit	Forsberg, Nilsaga, & Boström, 2015	Multiple Sclerosis	G1: VR intervention.	Many of the participants identified being able to walk faster and expressed feeling safer while walking than prior to the use of the Wii.	Anecdotal
Writing	**Xbox Kinect:** *Kinect Sports I*, *Kinect Joy Ride*, *Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in Writing (as part of the Jebsen Hand Function Test) between pretest and posttest results following the VR intervention.	Medium

Performance Skills	Use of Virtual technologies	Author, year	Population	Comparison to	Assertions/Outcomes	Level of evidence
Process Skills						
Activity Adherence	**Nintendo Wii:** *Wii Fit*	Yuen, et al., 2013	Systemic Lupus Erythematous	G1: VR intervention	Self-report of activity adherence correlated with the VR console log with 95% accuracy.	Medium
Multi-tasking	**Nintendo Wii:** Tilt, Tightrope, Soccer, Balance Bubble	Subramaniam, Hui-Chan, & Bhatt, 2014	Stroke, Community Dwelling	G1: VR intervention	There was a reduction in cognitive energy expenditure, making the ability to complete movement with minimal cognitive effort.	High
Regulates	**Nintendo Wii**	Shih, Wang, & Wang, 2014	Attention Deficit Hyperactivity Disorder	G1: VR intervention	Two participants showed significant increase in their ability to control and regulate impulsive standing during class due to the vibrating reminder from the Wii Remote.	Low
Social Interaction Skills						
Communication	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of communication as measured by the Parkinson's Disease Questionnaire (39 item) following interventions.	Medium
Social Interaction: Accommodates	**Nintendo Wii:** *Guitar Hero*, *Wii Sports*: Bowling	Janssen, Verschuren, Levac, Eemers, & Ketelaar, 2012	Traumatic Brain Injury, Adolescent	G1: VR intervention	The participant demonstrated an increase in the ability to accommodate for speech difficulty through gestures when interacting with other peers during VR play per self report.	Low

SECTION 4: PERFORMANCE PATTERNS

As VR changes in accessibility, form, and integration into everyday life, the application of VR to performance patterns may see the greatest significant change in applicability to practice compared to the other sections organized in this guide. Performance patterns include; habits, roles, routines, and rituals (AOTA, 2014), which is influenced notably by hand-held devices such as smart phones and the iPad. The technology that makes the Xbox Kinect and the Nintendo Wii unique in gesture interaction and movement-based activity may be harnessed in smaller form and available with mobile devices in the future. Currently, performance patterns are increasingly affected by the incorporation of VR with communication, scheduling, leisure activities, and time management as a few examples.

Table 4: Evidence-Based use of Virtual Technologies: Performance Patterns

Performance Pattern	Use of VR	Author, year	Population	Experimental Groups	Assertions/Outcomes	Level of evidence
Roles and Rituals	**Xbox Kinect**: *Your Shape Fitness Evolved:* Zen Energy	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	Emotional health, as measured by the Health-related Quality of Life, limited involvement in roles and rituals	High
Routines						
Engagement	**Nintendo Wii:** *Wii Fit, Wii Sports*	Bacon, Farnworth, & Boyd, 2012	Obesity, At Risk, Forensic Mental Health	G1: VR intervention	The VR intervention increased the participants' amount of physical activity, participants' attitudes towards exercise, and positive interaction with staff.	Low
Exercise Adherence	**Nintendo Wii:** *Wii Fit Plus:* (Balance Board games only)	Holmes, Gu, Johnson, & Jenkins, 2013	Parkinson's Disease	G1: VR intervention	Participants demonstrated strong adherence to the intervention with no significant change. They also reported motivation, enjoyment and interest in the home-based VR intervention.	Medium
Social Functioning	**Xbox Kinect:** Zen Energy	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	The group-based exercise group demonstrated a significant improvement in social functioning as measured by the Health Related Quality of Life. There was no significant improvement for the VR group.	High

Performance Pattern	Use of VR	Author, year	Population	Experimental Groups	Assertions/Outcomes	Level of evidence
Roles						
Role Participation	**Nintendo Wii:** Wakeboard, Frisbee dog, Jet ski, Canoe	Park, Lee, & Ko, 2013	Low-Back Pain, Chronic	G1: VR intervention G2: Stability exercise	The VR group demonstrated significantly improved participation in roles that were limited by: emotional problems, energy/fatigue, and emotional well-being.	High
Social Interaction	**Nintendo Wii:** *Wii Fit* (activities related to balance and aerobics)	Williams, Doherty, Bender, Mattox, & Tibbs, 2011	Well-Elderly	G1: VR intervention	Several participants stated that they enjoyed the benefits of the social interaction that was provided through use of the group-based VR intervention.	Anecdotal
Social Relationships	**Nintendo Wii:** Bowling	Bell et al., 2011	Well Elderly, Assisted Living Facilities	G1: VR intervention and fall prevention class G2: VR activities only G3: No intervention	The authors noted a positive increase in social relationships as a result of the use of the group-based VR intervention.	Anecdotal
Social Interaction	**Nintendo Wii:** *Wii Sports:* Bowling, Tennis, Golf, Boxing, Baseball	Wingham, Adie, Turner, Schofield, & Pritchard, 2015	Stroke, Caregiver	Control and VR Treatment	The VR intervention resulted in an increase in interaction with friends and family through an increase in relation to others, maintaining social roles, and providing social support.	High

Performance Pattern	Use of VR	Author, year	Population	Experimental Groups	Assertions/Outcomes	Level of evidence
Rituals						
Interaction with Younger Adults	**Nintendo Wii:** *Wii Sports, Sports Resort*, Tennis, Golf, Bowling, Sword Fighting, Archery, Boxing, Frisbee, Tennis, Cycling	Wollershein et al., 2010	Older Women	G1: VR intervention.	Participants experienced new opportunities to interact socially with others, an increase in feeling connected, and improvement in overall well-being.	Medium

SECTION 5: CONTEXT AND ENVIRONMENT

Because VR is considered a context in which therapy takes place, every journal article could fit into this section. Within the OTPF-3, context is the environment that surrounds the client and includes; cultural, personal, temporal, and virtual (AOTA, 2014). However, the researchers of this guide identified only the journal articles that pertained specifically to the relationship VR had to context. For example, Wingham, Adie, Turner, Schofield, and Pritchard (2015) specifically discussed the effect utilizing VR at home has on intervention, adherence, and social relationships. These authors were specifically seeking to understand how the virtual environment affected the results, not the intervention itself. The journal articles not included in this section may still utilize the context of VR to address function, but focus on elements such as client factors and performance skills. While this section may include less research, it remains a valuable section to this guide due to representing the versatility, adaptability, and future potential VR may have for therapy.

Table 5: Evidence-Based use of Virtual Technologies: Context and Environment

Context/ Environment	Use of Virtual technologies	Author, year	Population	Comparison to	Assertions/Outcomes	Level of evidence
Context: Virtual						
Activity Levels	**Nintendo Wii:** *Wii Fit:* Jogging, Bicycling, Snowboarding, Skiing	Robert, Ballaz, Hart, & Lemay, 2013	Cerebral Palsy, Children	G1: VR intervention G2: No intervention	There was no significant difference between the groups regarding activity levels. This supports the use of VR for this population to reach activity levels similar to the well population.	Medium
Activity Levels	**Nintendo Wii:** *Wii Sports:* Bowling, Boxing, Tennis **Xbox Kinect** *Your shape Fitness Evolved*: Tai Chi *Sports:* Bowling, Boxing, Tennis	Taylor, et al., 2012	Elderly	G1: VR intervention	The VR intervention produced light exercise with a MET range from 1.46-2.97. There was significant energy expenditure with no difference between playing standing or seated.	Medium
Enjoyment	Nintendo Wii fit and Wii Sports (Balance Board games)	Yohanna et al., 2011	Stroke	G1: VR intervention G2: Standard therapy	The VR group demonstrated greater improvements in enjoyment than the standard therapy group, however these improvements were not significant.	Medium
Enjoyment	**Nintendo Wii:** *Wii Sports:* Bowling, Tennis, Boxing *Dance Dance*	Howcroft, Klejman et al., 2012	Cerebral Palsy, Children	G1: VR intervention	All participants reported a high level of enjoyment during the VR intervention as measured by the Physical Activity Enjoyment Scale.	Medium

(Continued)	*Revolution:* Disney Dance Grooves					
Exercise Enjoyment	**Nintendo Wii:** *Wii Fit*	Nicholson, McKean, Lowe, Fawcett, & Burkett, 2015	Elderly	G1: VR intervention G2: No intervention	There were significant improvements for the VR group in exercise enjoyment as measure by the Physical Activity Enjoyment Scale.	Medium
Purposeful Movements	**Xbox Kinect:** Bowling	Rand, Givon, Weingarden , Nota, & Zeilig, 2014	Stroke	G1: VR intervention G2: Standard therapy	The VR group demonstrated that all movements used during VR activities were purposeful when compared to control group.	High
Safety	**Xbox Kinect:** *Adventures*: Space Pop, 20,000 Leaks, Reflex Ridge, River Rush	Pompeu et al., 2014	Parkinson's Disease	G1: VR intervention	There were no adverse events reported, such as convulsion, syncope, dizziness, vertigo, or falls indicating VR can be used safely and feasibly.	Low
Health Professional Usability Questionn-aire	Wii, Sports	Winkels, Kottink, Temmink, Nijlant, & Buurke, 2013	Cerebral Palsy, children	G1: VR intervention.	Therapists stated that the Wii could be used for a variety of populations including Cerebral Palsy, neuromuscular disorders, and developmental coordination disorders. They also acknowledged its potential use in both the clinic and at home.	Anecdotal
VR Environment for Success in School	**Nintendo Wii**	Shih, Wang, Chang, & Shih, 2012	Attention Deficit Hyperactivity Disorder	G1: VR intervention	The Wii remote was used as an assistive device by vibrating when children stood up as a way to help children remain focused and seated.	Low

VR Environment to Reduce Limb Hyperactivity	**Nintendo Wii**	Shih, Yeh, Shih, & Chang, 2011	Attention Deficit Hyperactivity Disorder	G1: VR intervention	Two of the participants demonstrated significant increase in ability to control and maintain a static limb in VR environment.	Low
Environment: Physical						
Home	**Nintendo Wii:** *Wii Sports:* Bowling, Tennis, Golf, Boxing, Baseball	Wingham, Adie, Turner, Schofield, & Pritchard, 2015	Stroke, Caregiver	G1: VR intervention G2: No intervention	Participants reported the VR was easy to set up and maintain. They also preferred participating within the home environment.	High
Environment: Social						
Social Interaction	**Nintendo Wii:** *Wii Sports, Sports Resort:* Tennis, Golf, Bowling, Sword Fighting, Archery, Boxing, Frisbee, Tennis, Cycling	Wollershein, et al., 2010	Older Women	G1: VR intervention	The VR provided new opportunities to interact with family and others. This increased connectedness with others and promoted improvement in well-being.	Medium

SECTION 6: ASSESSMENTS TOOLS

Not listed within any specific aspect of the domain of OT within the OTPF-3 (AOTA, 2014) are assessment tools. As assessment tools can be used to measure a variety of occupations, client factors, performance skills, and performance patterns at the same time; therefore the results of the assessments do not fit into any one of these categories, but within multiple categories. For example, the Box and Block test involves client factor of control of voluntary movement, performance skill of coordination, and many others. Due to this lack of ability to be easily categorized into one section based on the OTPF-3, this last section includes the use of assessment tools, such as the Box and Block Test, as outcome measures following the use of VR in therapy (AOTA, 2014). However, if the assessment tool subtest results were reported and fit within a specific category, such as the balance subtest within the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) as a client factor, the balance subtest results were reported in the *Client Factors* section of this guide and the overall BOT-2 results are reported in this *Assessment Tools* section of the guide. Due to the lack of simple categorization based on the OTPF-3 (AOTA, 2014), the assessment tools are reported in the following order:

Assessment Tools

Activities of Daily Living: ABILIHAND-Kids, Nottingham Extended Activities of Daily Living, Pittsburgh Sleep Quality Index

Ambulation/walking/standing: 30 Second Chair Stand Test; 1 Minutes Walk Test; 2 Minute Step Test; 2 Minute Walk Test; 6 Minutes Walk Test; 8 Foot Up-And-Go Test; 10 Meter Walking Test; 20 Meter Shuttle Run Test; Four Square Step Test; Five-Times-Sit-to-Stand-Test; Dynamic Gait Index; Gross Motor Function Measure; Muscle Power Sprint Test; Short Physical Performance Battery; Spatiotemporal gait parameters (GAITRite); Timed Up and Go Test;

Balance: Activities Specific Balance Confidence Scale; Balance Evaluation System Test; Balance Outcome Measure for Elder Rehabilitation; Berg Balance Scale; Center of Pressure; Fullerton Advanced Balance; Functional Reach Test; Lateral Reach Test; Mini-Balance Evaluation System Test; Multi-Directional Reach Test; Pediatric Reach Test; Single-leg Balance; miscellaneous balance measures

Cognition: Amsterdam Neuropsychological Tasks; Continuous Performance Test; Mini-Mental State Examination (Korean Version)

Coordination/Motor skills/Process Skills: Action Research Arm Test; Assessment of Motor and Process Skills; Bruininks-Oseretsky Test of Motor Proficiency; Development of Visual Perception; Functional Strength Measure; Lower Extremity Functional Scale; Modified Ashworth Scale; Rapid Assessment of Physical Activity; Test of Visual-Perceptual Skills; Timed Taping Task; Visual Motor Integration; Wolf Motor Function Test

Depression/Engagement/Motivation: 15 Item Geriatric Depression Scale; Beck Depression Inventory; Change Assessment Questionnaire; Children's Assessment of Participation and Engagement; Hamilton Depression Scale; Hospital Anxiety and Depression Scale; Intrinsic Motivation Inventory; Self-Efficacy for Exercise Scale

Dexterity: Box and Block Test; Nine Hole Peg Test; Purdue Pegboard Test

Falls/Falling: Falls Efficacy Scale

Functional ability: Co-ordination Skills Questionnaire; Fatigue Severity Scale; Fugle-Meyer Assessment; Functional Independence Measure; Gross Motor Function Test; Jebsen-Taylor Test of Hand Function; Manual Function Test; Melbourne

Assessment of Upper Limb function; Modified Barthel Index; Motor Assessment Scale; Motricity Index; Movement Assessment Battery for Children; Stroke Impact Scale; Unified Parkinson's Disease Rating Scale

Quality of Life: Control, Autonomy, Self-Realization, Pleasure-19; Parkinson's Disease Quality of Life Scale; Pediatric Quality of Life Inventory; SF-8 Health Survey; Social Provisions Scale; World Health Organization Quality of Life Questionnaire (Brief Australian Version)

Sensory integration/pain: McGill Pain Questionnaire (short form); Sensory Organization Test; Test of Sensory Integration Function

Miscellaneous: Global Performance

Table 6: Evidence-Based use of Virtual Technologies: Assessment Tools

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Category: Activities of Daily Living						
ABILHAND-Kids	**Nintendo Wii:** *Wii Sports*	Winkels, Kottink, Temmink, Nijlant, & Buurke, 2013	Cerebral Palsy, Children	G1: VR intervention	Participants demonstrated a significant improvement in the ABILIHAND-kids from baseline and high report of enjoyment using VR.	Medium
Nottingham Extended Activities of Daily Living (NEADL)	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention.	The participants demonstrated a significant increase in the results of the NEADL following intervention. Upon 1-month follow-up, there was a significant decrease in NEADL scores, demonstrating that the improvements were short-term.	Medium
Pittsburgh Sleep Quality Index	**Nintendo Wii:** *Wii Fit*	Yuen, Holthaus, Kamen, Sword, & Breland, 2011	Systemic Lupus Erythematosus, African American Women	G1: VR intervention	There was no significant difference in sleep quality as measure by the Pittsburgh Sleep Quality Index following intervention.	Medium
Category: Ambulation/Walking/Standing						
30-Second Chair Stand Test (30SCST)	Xbox Kinect Zen Energy	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	Both groups demonstrated a significant improvement in the 30SCST. Group one demonstrated significantly more improvement than group two.	High

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
10 Meter Walking Test	**Nintendo Wii**: *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	Neither group demonstrated significant improvements; however, greater gains were noted in the VR group than the standard therapy.	High
10-Meters Walk Test	**Xbox Kinect:** *Kinect Sports I, Kinect Joy Ride, Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements between pretest and posttest results of the 10-Meter Walk Test following the use of the Wii as an intervention strategy.	Medium
One-Minute Walk Test	**Nintendo Wii:** *Wii Fit*	AlSaif & Alsenany, 2015	Cerebral Palsy, Children	G1: VR intervention G2: No intervention	One-Minute Walk Test (Subtest of the Movement Assessment Battery for Children-2) results significantly increased in the VR group only.	High
2-Minute Step Test (2MST)	**Xbox Kinect:** *Zen Energy*	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise.	Both groups demonstrated a significant improvement in ambulation as measured by the 2MST.	High
2-Minute Walk Test (2-MWT)	**Nintendo Wii:** *Wii Fit*	Fung, Ho, Shaffer, Chung, & Gomez, 2012	Total Knee Replacement	G1: VR intervention G2: Lower extremity strengthening and balance	There was no significant difference between the Wii group and the lower extremity strengthening and balance group in relation to walking speed as measured by the 2-MWT following the intervention period.	High
2-Minute Walk Test (2MWT)	**Nintendo Wii:** *Wii Fit*	Imam, Miller, McLaren, Chapman, & Finlayson, 2013	Lower limb Amputation	G1: VR intervention	Results of the 2MWT increased to above 2 standard deviations following introduction of the VR into the intervention.	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
20 Meter Shuttle Run Test	**Nintendo Wii:** *Wii Fit*	Ferguson, Jelsma, Jelsma, & Smits-Englesman, 2013	Developmental Coordination Disorder, Children	G1: VR activities G2: Neuromotor Task Training	The 20 m Shuttle Run Test results indicated a significant improvement for both the NTT and the VR groups; however, the NTT group demonstrated greater improvements.	Medium
6-Minute Walk Test (6-MWT)	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention G2: Health education sessions	There was no significant difference in the results of the 6-MWT following the intervention period.	Medium
6-Minute Walk Test (6-MWT)	**Nintendo Wii**	Chao, Scherer, Wu, Lucke, & Montgomery, 2013	Assisted Living Residents	G1: VR intervention	The results of the 6-Minute Walk Test demonstrated improvements, however, these improvements were not significant.	Medium
6-Minute Walk Test (6MWT)	**Nintendo Wii:** *Wii Fit*	McClanachan, Gesch, Wuthapanich, Flemin, & Kuys, 2013	Acquired Brain Injury	G1: VR intervention in addition to standard therapy G2: standard therapy alone. Crossover trial	There were improvements in gait as measured by the 6MWT following both conventional therapy and Wii intervention, however, the results were not significant.	High
6-Minute Walk Test (6MWT)	**Xbox Kinect:** *Adventures*: Space Pop, 20,000 Leaks, Reflex Ridge, River Rush	Pompeu, et al., 2014	Parkinson's Disease	G1: VR intervention	There were no significant improvements in the results of the 6MWT following intervention.	Low

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
8-Foot Up-and-Go Test (8FUGT)	**Xbox Kinect:** *Zen Energy*	Lee, Son, Kim, & Yoon, 2015	Older Women	G1: VR intervention G2: Group-based exercise	Both groups demonstrated a significant improvement in ambulation as measured by the 8FUGT.	High
Four Square Step Test (FSST)	**Nintendo Wii:** *Wii Sports:* Baseball, Boxing, Golf, Tennis, 10-pin bowling)	Keogh, Power, Wooller, Lucas, Whatman, 2014	Elderly, Residential Aged-Care Center	G1: VR intervention G2: No intervention	There was no significant difference in the results of the FSST following the intervention period.	Medium
Five-Times-Sit-To-stand-Test	**Nintendo Wii:** *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	No significant difference was noted between the VR group and traditional therapy; however, greater gains were noted in the VR group.	High
Dynamic Gait Index (DGI)	**Xbox Kinect:** *Adventures*: Space Pop, 20,000 Leaks, Reflex Ridge, River Rush	Pompeu, et al., 2014	Parkinson's Disease	G1: VR intervention	There were no significant improvements in the results of the DGI following intervention.	Low
Gross Motor Function Measure (GMFM)-Dimension D (Standing)	**Nintendo Wii:** *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	No significant difference was noted between the VR group and traditional therapy; however, greater gains were noted in the VR group.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Gross Motor Function Measure (GMFM)-Dimension E (Walking, Running, Jumping)	**Nintendo Wii:** *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	No significant difference was noted between the VR group and traditional therapy; however, greater gains were noted in the VR group.	High
Muscle Power Sprint Test	**Nintendo Wii:** *Wii Fit*	Ferguson, Jelsma, Jelsma, & Smits-Englesman, 2013	Developmental Coordination Disorder, Children	G1: VR activities G2: Neuromotor Task Training (NTT).	The Muscle Power Sprint Test results indicated a significant improvement for both the NTT and VR groups, however, the NTT group demonstrated greater improvements.	Medium
Short Physical Performance Battery (SPPB)	**Nintendo Wii:** *Wii Fit*	Imam, Miller, McLaren, Chapman, & Finlayson, 2013	Lower Limb Amputation	G1: VR intervention	Four of six participants demonstrated significant improvement in the results of the SPPB.	Medium
Spatiotemporal Gait Parameters (GAITRite) (Continued)	**Nintendo Wii:** *Wii Fit*	McClanachan, Gesch, Wuthapanich, Flemin, & Kuys, 2013	Acquired Brain Injury	G1: VR intervention in addition to standard therapy G2: Standard therapy alone (Cross-over trial)	There were improvements in gait following both conventional therapy and Wii intervention, however the results were insignificant.	High
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Fit*	Bieryla & Dold, 2013	Well-Elderly	G1: VR intervention G2: No intervention	There was no significant increase in TUG scores in either the Wii or control groups.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention G2: Health educational sessions	The VR group demonstrated a significant improvement in the TUG compared to the education group.	Medium
Timed Up and Go (TUG) Test	**Nintendo Wii**	Chao, Scherer, Wu, Lucke, & Montgomery, 2013	Assisted Living Residents	G1: VR intervention.	The results of the Timed Up and Go Test demonstrated improvements following the intervention, however, these improvements were not significant.	Medium
Timed Up and Go (TUG) Test	**Nintendo Wii**: Balance Bubble, Ski Slolam, Ski Jump, Soccer Heading, Table Tilting, and Penguin Slide	Cho, Lee, & Song, 2012	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy	There was a significant improvement in the results of the TUG test following intervention with a significantly greater improvement in the VR group than the standard therapy group.	High
Timed Up and Go (TUG) Test	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz, et al, 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of the TUG following intervention.	Medium
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Fit*	Nicholson, McKean, Lowe, Fawcett, & Burkett, 2015	Elderly	G1: VR intervention G2: No intervention	There were significant improvements for the VR group in the results of the TUG following the intervention.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Fit*	Park, Kim, & Lee, 2015	Elderly individuals	G1: VR intervention G2: Ball exercise	Following the intervention, both groups demonstrated a significant decrease in TUG time. However, the VR group demonstrated greater improvements.	Medium
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Fit*: Table Tilt, Tightrope, Penguin Slide	Prata & Scheider, 2014	Elderly Fallers, Female	G1: VR intervention	There was a significant increase in mobility as measured by the TUG following the VR intervention.	Medium
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	No significant difference was noted between the Wii group and traditional therapy; however, greater gains were noted in the Wii group.	High
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Sport, Wii Fit*	Salem, Gropak, Coffin, & Godwin, 2012	Developmental Delay, Children	G1: VR intervention G2: Standard therapy	No significant difference was noted between the Wii group and traditional therapy; however, greater gains were noted in the Wii group.	High
Timed Up and Go (TUG) Test	**Nintendo Wii**: Tilt, Tightrope, Soccer, Balance Bubble	Subramaniam, Hui-Chan, & Bhatt, 2014	Stroke, Community Dwelling	G1: VR intervention	There were moderate improvements in the results of the TUG; however, these results were not significant.	High
Timed Up and Go (TUG) Test	**Nintendo Wii**	Tatla, Radomski, Cheung, Maron, & Jarus, 2014	Traumatic Brain Injury, Children	G1: VR intervention	There was a significant improvement in 1 participant and non-significant improvement in the other 3 following the VR intervention.	Low
Timed Up and Go (TUG) Test	**Nintendo Wii:** *Wii Sports*; **Xbox Kinect**: *Sports*	Taylor, et al., 2012	Older Adults	G1: VR intervention	No significant improvement was observed.	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Category: Balance						
Activities-Specific Balance Confidence Scale (ABCS)	**Nintendo Wii:** *Wii Fit*	Bainbridge, Bevans, Keeley, & Oriel, 2011	Community-Dwelling Older Adults	G1: VR intervention	There was no significant difference in the Activities-Specific Confidence Scale following intervention.	Medium
Activities-Specific Balance Confidence Scale (ABCS)	**Nintendo Wii:** *Wii Fit*	Fung, Ho, Shaffer, Chung, & Gomez, 2012	Total Knee Replacement	G1: VR intervention G2: Lower extremity strengthening and balance	There was no significant difference between the Wii group and the lower extremity strengthening and balance group as measured by the ABCS following the intervention period.	High
Activities-Specific Balance Confidence Scale (ABCS)	**Nintendo Wii:** *Wii Fit Plus*	Holmes, Gu, Johnson, & Jenkins, 2013	Parkinson's Disease	G1: VR intervention	There were no significant differences in balance confidence as measured by the ABCS following the intervention period; however, balance confidence was improved at mid-intervention prior to reverting to baseline.	Medium
Activities-Specific Balance Confidence Scale (ABCS)	**Nintendo Wii:** *Wii Fit*	Imam, Miller, McLaren, Chapman, & Finlayson, 2013	Lower Limb Amputation	G1: VR intervention	Three of six participants demonstrated significant increase in the results of the ABCS following introduction of the Wii to the therapy session.	Medium
Balance Evaluation System Test (BESTest)	**Xbox Kinect:** *Adventures*: Space Pop, 20,000 Leaks, Reflex Ridge, River Rush	Pompeu, et al., 2014	Parkinson's Disease	G1: VR intervention	There was a significant improvement in balance as measured by the BESTest following VR intervention.	Low

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Balance Outcome Measure for Elder Rehabilitation (BOOMER)	**Nintendo Wii:** *Wii Fit*	McClanachan, Gesch, Wuthapanich, Flemin, & Kuys, 2013	Acquired Brain Injury	G1: VR intervention in addition to standard therapy G2: Standard therapy alone. (Cross-over trial)	There were improvements in the BOOMER following both conventional therapy and Wii intervention; however, the results were not significant.	High
Berg Balance Scale (BBS)	**Nintendo Wii:** *Wii Fit:* Soccer Heading, Ski Jump, Ski Slalom, Table Tilt, Tightrope Walk	Bainbridge, Bevans, Keeley, & Oriel, 2011	Community-Dwelling Older Adults	G1: VR intervention	A majority (4/6) of the participants demonstrated an increased score on the Berg Balance Scale; however the results were not significant.	Medium
Berg Balance Scale (BBS)	**Nintendo Wii:** *Wii Fit*	Bieryla & Dold, 2013	Well-Elderly	G1: VR intervention G2: No intervention	BBS scores significantly increased in the VR group only following the intervention period.	Medium
Berg Balance Scale (BBS)	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention G2: Health education sessions	The results of the BBS indicated a significant difference in balance of the Wii group when compared to the education group.	Medium
Berg Balance Scale (BBS)	**Nintendo Wii:** Balance Bubble, Ski Slolam, Ski Jump, Soccer Heading, Table Tilting, Penguin Slide	Cho, Lee, & Song, 2012	Stroke	G1: Standard therapy and VR intervention. G2: Standard therapy alone	There was a significant improvement in the results of the Berg Balance Scale following intervention with a significantly greater improvement in the VR group than in the standard therapy group.	High

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Berg Balance Scale (BBS)	**Nintendo Wii**: K-Pop Dance Festival	Nam-Yong, Dong-Kyu, & Hyun-Seung, 2015	Parkinson's Disease	G1: VR intervention in addition to neurodevelopmental treatment and functional electrical stimulation G2: neurodevelopmental treatment and functional electrical stimulation alone.	The VR group demonstrated a significant improvement in balance as measured by the Berg Balance Scale. The control group demonstrated no significant improvement.	Medium
Berg Balance Scale (BBS)	**Nintendo Wii:** Tilt, Tightrope, Soccer, Balance Bubble	Subramaniam, Hui-Chan, & Bhatt, 2014	Stroke, Community Dwelling	G1: VR intervention	There was moderate improvement in the results of the BBS, which were not significant.	Medium
Berg Balance Scale-15 (BBS)	**Nintendo Wii**	Chao, Scherer, Wu, Lucke, & Montgomery, 2013	Assisted Living Residents	G1: VR intervention	There was a significant improvement in balance as measured by the Berg Balance Scale.	Medium
Center of Pressure	**Nintendo Wii:** *Wii Fit*	Bainbridge, Bevans, Keeley, & Oriel, 2011	Community-Dwelling Older Adults	G1: VR intervention	There was no significant difference in balance demonstrated by the results of the Center of Pressure measure.	Medium
Fullerton Advanced Balance (FAB)	**Nintendo Wii:** *Wii Fit*	Bieryla & Dold, 2013	Well-Elderly	G1: VR intervention G2: No intervention	There was no significant increase in FAB scores in either the Wii or control groups.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Functional Reach (FR) Test	**Nintendo Wii:** *Wii Fit*	Bieryla & Dold, 2013	Well-Elderly	G1: VR intervention G2: No intervention	There was no significant increase in FR scores in either the Wii or control groups.	Medium
Modified Functional Reach Test (MFRT)	**Nintendo Wii**	Tatla, Radomski, Cheung, Maron, & Jarus, 2014	Traumatic Brain Injury, Children	G1: VR intervention	There was a significant improvement in 1 participant and improvements that were not significant in the other 3.	Low
Lateral Reach	**Nintendo Wii:** *Wii Fit*	Nicholson, McKean, Lowe, Fawcett, & Burkett, 2015	Elderly	G1: VR intervention G2: No intervention	There were significant improvements for the VR group in the results of the lateral reach for both left and right following the intervention.	Medium
Mini-Balance Evaluation System Test (mini-BESTest)	**Nintendo Wii:** *Wii Sports*; **Xbox Kinect**	Taylor, et al., 2012	Elderly	G1: VR intervention	No significant improvement in the mini-BESTest was observed following intervention.	Medium
Multi-Directional Reach Test	**Nintendo Wii:** *Wii Fit:* Soccer Heading, Ski Jump, Ski Slalom, Table Tilt, Tightrope Walk	Bainbridge, Bevans, Keeley, & Oriel, 2011	Community-Dwelling Older Adults	G1: VR intervention	The results of the Multi-Directional Reach Test were not significant following VR use.	Medium
PRT (Pediatric Reach Test)	**Xbox Kinect:** *Kinect Sports I, Kinect Joy Ride, Kinect Disneyland*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in the Pediatric Reach Test between pretest and posttest results following the use of the Wii as an intervention strategy.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(Continued)	*Adventures*					
Single-Leg Balance	**Nintendo Wii:** *Wii Fit*	Nicholson, McKean, Lowe, Fawcett, & Burkett, 2015	Elderly	G1: VR intervention G2: No intervention	There were significant improvements for the VR group in the results of the single-leg stance for the left leg only following the intervention.	Medium
Balance (as measured by the Movement Assessment Battery for Children [M-ABC])	**Nintendo Wii:** *Wii Fit Plus*	Esposito, et al., 2013	Migrane without Aura, Children	G1: VR intervention for children with MoA G2: No intervention for typically developing children	The Wii group demonstrated significant improvements in the balance aspect of the M-ABC. There were no significant improvements in the control group.	High
Composite Equilibrium Score	**Xbox Kinect**	Ortiz-Gutiérrez, et al., 2013	Multiple Sclerosis	G1: telerehabilitation VR intervention G2: Standard physiotherapy	The VR group demonstrated significant improvement in the composite equilibrium score. The control group demonstrated no significant improvements.	High
Dynamic Balance Ability (Combined Berg Balance Scale and Timed up and go test)	**Nintendo Wii:** Balance Bubble, Ski Slolam, Ski Jump, Soccer Heading, Table Tilting, Penguin Slide	Cho, Lee, & Song, 2012	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy	There was a significant improvement in the results of the dynamic standing balance following intervention with a significantly greater improvement in the Nintendo Wii group than in the control group.	High

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Static Balance Abilities	**Nintendo Wii**	Cho, Lee, & Song, 2012	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy	There was no significant difference in either group for static balance.	High
Category: Cognition						
Amsterdam Neuropsychological Taken (ANT)	**Nintendo Wii**	De Kloet, Berger, Verhoeven, Van Stein Callenfels, & Vliet Vlieland, 2012	Acquired Brain Injury, Youth	G1: VR intervention	There was a significant improvement in the speed of information processing following intervention related to reaction time, figure identification, shifting attention, visual motor coordination and response inhibition as measured by the ANT.	Medium
Continuous Performance Test	**Nintendo Wii:** *Sports Resort*: Swordplay, Table Tennis, Canoe	Choi et al., 2014	Stroke, Sub-acute	G1: Standard therapy and VR intervention G2: Standard therapy	There was a significant increase in the results of the Continuous Performance Test in both groups demonstrates that the Wii is as effective as conventional therapy.	High
Mini-Mental State Examination (Korean Version)	**Nintendo Wii:** *Sports Resort:* Swordplay, Table Tennis, Canoe	Choi, et al., 2014	Stroke, Sub-acute	G1: Standard therapy and VR intervention G2: Standard therapy	There was a significant increase in theresults of the Korean version of the Mini-Mental State Examination in both groups.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Category: Coordination/Motor Skills/Process Skills						
Action Research Arm Test	**Xbox Kinect:** Bowling	Rand, Givon, Weingarden, Nota, & Zeilig, 2014	Stroke	G1: VR intervention G2: Standard therapy	There was significant higher intensity and increased repetition of upper extremity movements found in VR group compared to control.	High
Assessment of Motor and Process Skills (AMPS)-Motor Skills	**Xbox Kinect**	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in Motor Skills between pretest and posttest results following the use of the Wii as an intervention strategy.	Medium
Assessment of Motor and Process Skills (AMPS)-Process Skills	**Xbox Kinect**	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention	There were significant improvements in Process Skills between pretest and posttest results following VR intervention.	Medium
Bruininks-Oseretsky Test of Motor Proficiency, 2nd Edition (BOT-2)	**Nintendo Wii:** *Wii Fit*	Hammond, Jones, Hill, Green, & Male, 2012	Developmental Coordination Disorder, Children	G1: VR intervention G2: Jump Ahead programme (crossover study)	Both groups demonstrated improved BOT-2 scores following the VR intervention period; however, the improvements were not significant.	Medium
Bruininks-Oseretsky Test of Motor Proficiency (BOT)	**Nintendo Wii:** *Wii Fit*	AlSaif & Alsenany, 2015	Cerebral Palsy, Children	G1: VR intervention G2: No intervention	The results of the BOT significantly increased in the VR group only.	High
Bruininks-Oseretsky Test of Motor Proficiency,	**Nintendo Wii**	Berg, Becker, Martian, Primrose, & Wingen, 2012	Down Syndrome, Child	G1: VR intervention	The individual demonstrated an overall increase in the score of the BOT-2 following the VR intervention.	Low

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(Continued) **Second Edition (BOT-2)**						
Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2)	**Nintendo Wii:** *Wii Fit Plus*	Mombarg, Jelsma, & Hartman, 2013	Poor Motor Performance, Children	G1: VR intervention G2: No intervention	Both the control and experimental groups demonstrated increase in BOT-2 results; however, only the VR group had improvements that were significant.	High
Bruinins-Oseretsky Test of Motor Proficiency-Second Edition (BOT-2)	**Nintendo Wii**	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significant improvements in the fine motor integration, upper-limb coordination, and running speed and agility subtests of the BOT-2 when compared to the standard OT and no intervention groups.	High
Developmental Test of Visual Perception (DVTP-2) Korean Version	**Nintendo Wii**	Shin, Song, & Hwangbo, 2015	Cerebral Palsy	G1: VR intervention G2: Standard neurological physical therapy	There were significant improvements in the results of the DVPT-2 (Eye-hand coordination/visual-motor speed subtests) for both groups.	Low
Functional Strength Measure (FSM)	**Nintendo Wii:** *Wii Fit*	Ferguson, Jelsma, Jelsma, & Smits-Englesman, 2013	Developmental Coordination Disorder, Children	G1: VR activities G2: Neuromotor Task Training (NTT)	The NTT group demonstrated improvement on 6/9 FSM items, while the Wii group demonstrated improvement on 1/9 items.	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Lower Extremity Functional Scale (LEFS)	**Nintendo Wii:** *Wii Fit*	Fung, Ho, Shaffer, Chung, & Gomez, 2012	Total Knee Replacement	G1: VR intervention G2: Lower extremity strengthening and balance	There was no significant difference between the VR group and the lower extremity strengthening and balance group as measured by the LEFS following the intervention period.	High
Modified Ashworth Scale (MAS)	**Nintendo Wii**	Joo, et al., 2010	Stroke	G1: VR intervention.	There was no significant improvement in the results of the MAS following intervention.	Medium
Rapid Assessment of Physical Activity (RAPA)	**Nintendo Wii:** *Wii Sports:* Baseball, Boxing, Golf, Tennis, 10-pin bowling	Keogh, Power, Wooller, Lucas, Whatman, 2014	Elderly, Residential Aged-Care Center	G1: VR intervention G2: No intervention	The VR group demonstrated a significant increase in physical activity levels as measured by the RAPA following the intervention period when compared to the control group.	Medium
Test of Visual-Perceptual Skills, third edition (TVPS-3)	**Nintendo Wii**	Deutsch, Borbely, Filler, Huhn, & Guarrera-Bowlby, 2008	Cerebral Palsy, Child	G1: VR intervention	Improvements were noted in all aspects of the TVPS-3 except for visual-memory, and ranged from 4th percentile to 70th percentile improvements.	Low
Timed Tapping Task	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of the right-sided Timed Tap score following intervention.	Medium
Visual Motor Integration (VMI)-Motor Tasks	**Nintendo Wii:** *Wii Fit Plus*	Esposito, et al., 2013	Migrane without Aura, Children	G1: VR intervention for children with MoA	The Wii group demonstrated significant improvements in the motor skills o the VMI. There were no significant improvements in the	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(continued)				G2: No intervention for typically developing children	control group.	
WMFT; Wolf Motor Function Test	**Nintendo Wii**	Thompson-Butel, Lin, Shnier, & McNulty, 2015	Stroke	All groups received VR intervention G1: Low-functioning G2: Moderate functioning G3: High functioning	The VR intervention resulted in significant improvements in the results of the WMFT.	High
Wolf Motor Function Test (WMFT)	**Nintendo Wii:** *Wii Sports, Cooking Mama*	Saposnik, et al., 2010.	Stroke	G1: VR intervention in addition to standard intervention G2: Recreation therapy in addition to standard therapy	There was a significant increase in the WMFT by the VR group compared to recreation group.	High
Wolf Motor Function Test (WMFT)	**Nintendo Wii:** *Wii Sports*	Shiner, Byblow, & McNulty, 2014	Stroke	G1: VR intervention with priming. G2: VR intervention alone (CG)	Both groups demonstrated improvements in the results of the WMFT following intervention.	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Category: Depression/Engagement/Motivation						
15 item Geriatric Depression Scale (GDS-15)	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention G2: Health education sessions	The Wii group displayed significantly fewer depression signs than the education group following the intervention period as measured by the GDS-15	Medium
Beck Depression Inventory	**Nintendo Wii:** *K-Pop Dance Festival*	Nam-Yong, Dong-Kyu, & Hyun-Seung, 2015	Parkinson's Disease	G1: VR intervention in addition to neurodevelopmental treatment and functional electrical stimulation G2: neurodevelopmental treatment and functional electrical stimulation alone	The VR group demonstrated a significant improvement in depression status as measured by the Beck Depression Inventory. The control group demonstrated no significant improvement.	Medium
Change Assessment Question-naire (CAQ)	**Nintendo Wii:** *Wii Fit*	McClanachan, Gesch, Wuthapanich, Flemin, & Kuys, 2013	Acquired Brain Injury	G1: VR intervention in addition to standard therapy G2: standard therapy alone. (Cross-over trial)	The number of participants identifying with the "Change" stage of the CAQ was greatest following the VR intervention; however, these results were insignificant.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Children's Assessment of Participation and Engagement (CAPE)	**Nintendo Wii**	De Kloet, Berger, Verhoeven, Van Stein Callenfels, & Vliet Vlieland, 2012	Acquired Brain Injury, Youth	G1: VR intervention	Following the intervention, there was a significant decrease in the diversity of physical activity and a significant increase in intensity of activity as reported by the CAPE. There was no significant difference in the context or enjoyment as measured by the CAPE.	Medium
Hamilton Depression Scale (HAM-D)	**Nintendo Wii**: Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a trend toward improvement in depression as measured by the HAM-D, however improvements were not significant.	Medium
Hospital Anxiety and Depression Scale	**Nintendo Wii:** *Wii Fit*	Yuen, Holthaus, Kamen, Sword, & Breland, 2011	Systemic Lupus Erythematosus, African American Women	G1: VR intervention	There was a significant improvement in emotional state as measured by the Hospital Anxiety and Depression Scale following the VR intervention.	Medium
Intrinsic Motivation Inventory (IMI)	**Nintendo Wii:** Tilt, Tightrope, Soccer, Balance Bubble	Subramaniam, Hui-Chan, & Bhatt, 2014	Stroke, Community Dwelling	G1: VR intervention	There was a significant improvement in the results of the IMI, indicating an increase in adherence to interventions.	High
Self-Efficacy for Exercise Scale (SEE)	**Nintendo Wii Fit**	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly ,Assisted Living Facilities	G1: VR Intervention G2: Health education sessions	There was no significant difference between the groups regarding self-efficacy as measured by the SEE.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Category: Dexterity						
Box & Block Test (BBT)	**Nintendo Wii:** Bowling and Boxing	Chen, et al., 2014	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy and UE exercises. G3: Standard therapy and XavixPort Gloves	The VR group did not demonstrate a significant difference in the Box and Block Test following the intervention.	Medium
Box & Block Test (BBT)	**Nintendo Wii:** *Sports Resort:* Swordplay, Table Tennis, and Canoe Games	Choi, et al., 2014	Stroke, Sub-acute	G1: Standard therapy and VR intervention G2: Standard therapy.	There was a significant increase in the results of the Box and Block Test in both groups.	High
Box & Block Test (BBT)	**Nintendo Wii**	Paquin, et al., 2015	Stroke, Chronic	G1: VR intervention	There were significant improvements in the results of the BBT following the VR intervention.	Medium
Box & Block Test (BBT)	**Nintendo Wii:** *Wii Sports, Cooking Mama*	Saposnik, et al., 2010.	Stroke	G1: VR intervention in addition to standard intervention G2: Recreation therapy in addition to standard therapy	There was a significant increase in the results of the BBT for both groups.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Box & Block Test (BBT)	**Xbox Kinect:** *Sports, Adventure*	Sin & Lee, 2013	Stroke	G1: VR intervention in addition to standard therapy. G2: standard therapy alone	There was a significant improvement in the results of the Box and Block Test for both groups, with a significantly greater improvement in the VR group than the conventional therapy only group.	High
Nine Hole Peg Test (NHPT)	**Nintendo Wii**: Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of the 9-Hole Peg test following intervention for the right hand only.	Medium
Nine Hole Peg Test (NHPT)	**Nintendo Wii**	Paquin, et al., 2015	Stroke, Chronic	G1: VR intervention	There were significant improvements in the results of the NHPT following the VR intervention.	Medium
Purdue Pegboard Test	**Nintendo Wii**: Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of the Purdue Pegboard Test following intervention on the left side only.	Medium
Category: Falls/Falling						
Falls Efficacy Scale	**Nintendo Wii**	Chao, Scherer, Wu, Lucke, & Montgomery, 2013	Assisted Living Residents	G1: VR intervention	There were improvements in fear of falling as measured by the Falls Efficacy Scale; however, these improvements were not significant.	Medium
Falls Efficacy Scale (FES)	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention G2: Health education sessions	There was no significant difference between the groups regarding self-efficacy as measured by the FES.	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Falls Efficacy Scale-International (FES-I)	**Nintendo Wii:** *Wii Fit:* Table Tilt, Tightrope, Penguin Slide	Prata & Scheider, 2014	Elderly Fallers, Female	G1: VR intervention	There was a significant decrease in fear of falling following the VR intervention as measured by the FES-I).	Medium
Modified Falls Efficacy Scale	**Nintendo Wii;** Bowling	Bell, et al., 2011	Well Elderly, Assisted Living Facilities	G1: VR intervention and fall prevention class G2: VR activities only G3: No intervention	No significant difference was noted for any of the three groups overall. However, the researchers found significant differences on individual items of the assessment.	Medium
Category: Functional ability						
Coordination Skills Questionnaire (CSQ)	**Nintendo Wii:** *Wii Fit*	Hammond, Jones, Hill, Green, & Male, 2012	Developmental Coordination Disorder, Children	G1: VR intervention G2: Jump Ahead programme (crossover study)	Both groups demonstrated improved CSQ results throughout the VR intervention period; however, the improvements were not significant.	Medium
Fatigue Severity Scale	**Nintendo Wii:** *Wii Fit*	Yuen, Holthaus, Kamen, Sword, & Breland, 2011	Systemic Lupus Erythematosus, African American Women	G1: VR intervention.	There was a significant reduction in fatigue as measured by the Fatigue Severity Scale following the VR intervention.	Medium
Fugl-Meyer Assessment (FMA)	**Nintendo Wii**: Bowling and Boxing	Chen, et al., 2014	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy and UE exercises G3: Standard	All three groups demonstrated a significant difference in the Fugle-Meyer Assessment compared to pretest.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(continued)				therapy and XavixPort Gloved.		
Fugl-Meyer Assessment (FMA)	**Nintendo Wii:** *Sports Resort:* Swordplay, Table Tennis, and Canoe Games	Choi, et al., 2014	Stroke, Sub-acute	G1: VR intervention in addition to standard therapy and G2: Standard therapy	There was a significant increase in the results of the Fugle-Meyer Assessment in both groups.	High
Fugl-Meyer Assessment (FMA)	**Nintendo Wii**	Joo, et al., 2010	Stroke	G1: VR intervention	There was a significant improvement in the results of the FMA following the VR intervention.	Medium
Fugl-Meyer Assessment (FMA)	**Xbox Kinect:** *Sports, Adventure*	Sin & Lee, 2013	Stroke	G1: VR intervention in addition to standard therapy G2: Standard therapy alone	There was a significant improvement in the results of the Fugle-Meyer Assessment for both groups, with a significantly greater improvement in the VR group than the conventional therapy alone group.	High
Fugle-Meyer Assessment (FMA), Upper Extremity	**Xbox Kinect:** Bowling	Rand, Givon, Weingarden, Nota, & Zeilig, 2014	Stroke	G1: VR intervention G2: Standard therapy	There was a significantly higher intensity and increase in repetition within the VR group compared to the standard therapy group.	High
Fugle-Meyer Assessment (FMA), Upper Extremity	**Nintendo Wii:** *Wii Sports*	Shiner, Byblow, & McNulty, 2014	Stroke	G1: VR intervention with priming G2: VR intervention alone	The VR with priming group demonstrated a significant improvement in the results of the FMA by twice as much as the VR alone group.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Fugle-Meyer Assessment (FMA), Upper Extremity	**Nintendo Wii**	Thompson-Butel, Lin, Shnier, & McNulty, 2015	Stroke	All groups received VR intervention G1: Low functioning individuals G2: Moderate functioning individuals G3: High functioning individuals	All three groups demonstrated significant difference in the Fugle-Meyer Assessment.	High
Functional Independence Measure (FIM)	**Nintendo Wii**: Bowling and Boxing	Chen, et al., 2014	Stroke	G1: Standard therapy and VR intervention G2: Standard therapy and UE exercises G3: Standard therapy and XavixPort Gloved.	All three groups demonstrated a significant improvement in the Functional Independence Measure compared to pretest.	Medium
Functional Independence Measure (FIM)	**Xbox Kinect:** *Sports*	Lee, 2013	Stroke, Chronic	G1: VR intervention and standard therapy G2: Standard therapy alone	There were significant improvements in the in the results of the FIM in the VR group when compared to the control group.	High
Gross Motor Function Test (GMFT)	**Xbox Kinect**	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention.	There were significant improvements between pretest and posttest results of the GMFT following the use of the Wii.	Medium

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Jebsen-Taylor Test of Hand Function (JHFT)	**Nintendo Wii**	Fan, et al., 2014	Stroke	G1: VR intervention G2: Standard therapy G3: Board game intervention G4: No intervention	There were no significant differences in any group as measured by the JHFT.	High
Jebsen-Taylor Test of Hand Function (JHFT)	**Xbox Kinect:** *Kinect Sports I, Kinect Joy Ride, Kinect Disneyland Adventures*	Luna-Oliva et al., 2013	Cerebral Palsy, Children	G1: VR intervention.	There were significant improvements in all aspects of the JHFT except for picking up large heavy object between pretest and posttest results following the VR intervention.	Medium
Jebsen-Taylor Test of Hand Function (JHFT)	**Nintendo Wii**	Paquin, et al., 2015	Stroke, chronic	G1: VR intervention.	There were significant improvements in the results of the JHFT following intervention with the Wii.	Medium: IIIB2b
Manual Function Test	**Nintendo Wii:** *Sports Resort:* Swordplay, Table Tennis, Canoe	Choi, et al., 2014	Stroke, Sub-acute	G1: Standard therapy and VR intervention G2: Standard therapy	There was a significant increase in the results of the Manual Function Test in both groups.	High

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Melbourne Assessment of Upper Limb Function	**Nintendo Wii:** *Wii Sports*	Winkels, Kottink, Temmink, Nijlant, & Buurke, 2013	Cerebral Palsy, Children	G1: VR intervention	There was no significant improvement in upper extremity function as measured by the Melbourne Assessment of Upper Limb Function.	Medium
Modified Barthel Index	**Nintendo Wii:** *K-Pop Dance Festival*	Nam-Yong, Dong-Kyu, & Hyun-Seung, 2015	Parkinson's Disease	G1: VR intervention, neurodevelopmental treatment, and functional electrical stimulation G2: Neurodevelopmental treatment and functional electrical stimulation alone	The VR group demonstrated a significant improvement in activities of daily living as measured by the Modified Barthel Index. The control group demonstrated no significant improvement.	Medium
Modified Barthel Index (Korean Version)	**Nintendo Wii:** *Sports Resort:* Swordplay, Table Tennis, Canoe	Choi, et al., 2014	Stroke, Sub-acute	G1: Standard therapy and VR intervention G2: Standard therapy	There was a significant increase in the results of the Korean version of the Modified Barthel Index in both groups.	High
Motor Assessment Scale (MAS) Upper Extremity	**Nintendo Wii**	Thompson-Butel, Lin, Shnier, & McNulty, 2015	Stroke	All groups received VR intervention G1: Low functioning individuals G2: Moderate functioning	Only the High-functioning group demonstrated significant differences in the results of the MAS.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(continued)				individuals G3: High functioning individuals		
Motricity Index	**Nintendo Wii**	Joo, et al., 2010	Stroke	G1: VR intervention	There was a significant improvement in the results of the Motricity Index following the VR intervention.	Medium
Movement Assessment Battery for Children-2 (mABC-2)	**Nintendo Wii:** *Wii Fit*	AlSaif & Alsenany, 2015	Cerebral Palsy, Children	G1: VR intervention G2: No intervention	Overall, the results of the Movement Assessment Battery for Children-2 significantly increased in the VR group only.	High
Movement Assessment Battery for Children-2 (MABC-2)	**Nintendo Wii:** *Wii Fit*	Ferguson, Jelsma, Jelsma, & Smits-Englesman, 2013	Developmental Coordination Disorder, Children	G1: VR activities G2: Neuromotor Task Training (NTT)	Following the intervention period, there was no significant difference between the VR group and the NTT group as measured by the mean total standard score; however, only the NTT group demonstrated a significant improvement.	Medium
Movement Assessment Battery for Children-2 (mABC-2)	**Nintendo Wii:** *Wii Fit Plus*	Mombarg, Jelsma, & Hartman, 2013	Poor motor performance, children	G1: VR intervention G2: No intervention	Both groups demonstrated increase in mABC-2 results, however, only the VR group had significant improvements.	High
Stroke Impact Scale (SIS)	**Nintendo Wii**	Fan, et al., 2014	Stroke	G1:VR intervention G2: Standard therapy G3: Board game intervention	There was no significant difference as measured by the SIS.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
(Continued)				G4: No intervention		
Stroke Impact Scale (SIS)	**Nintendo Wii**	Paquin, et al., 2015	Stroke, Chronic	G1: VR intervention	There were improvements in the results of the JHFT following intervention with the Wii. However, the results were not significant.	Medium
Stroke Impact Scale (SIS)	**Nintendo Wii:** *Wii Sports, Coking Mama*	Saposnik, et al., 2010.	Stroke	G1: VR intervention and standard intervention G2: Recreation therapy and standard therapy	Both groups demonstrate a significant improvement in the results of the SIS following intervention. There was no significant difference between the groups.	High
Unified Parkinson's Disease Rating Scale (UPDRS)	**Nintendo Wii:** Tennis, Bowling, Boxing	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant improvement in the results of the UPDRS motor score following intervention.	Medium
Category: Quality of Life						
Control, Autonomy, Self-Realization, Pleasure-19	**Nintendo Wii:** Bowling	Bell, et al., 2011	Well Elderly, Assisted Living Facilities	G1: VR intervention and fall prevention class G2: VR activities only G3: No intervention	No significant difference was noted for any of the three groups overall. However, the researchers found significant differences on individual items of the assessment.	Medium
Parkinson's Disease Quality of	**Nintendo Wii:** Tennis, Bowling,	Herz, et al., 2013	Parkinson's Disease	G1: VR intervention	There was a significant positive difference in the results of the PDQ-39 following VR intervention	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Life (continued) **Scale (PDQ-39)**	Boxing					
Pediatric Quality of Life Inventory (PedsQL)	**Nintendo Wii**	De Kloet, Berger, Verhoeven, Van Stein Callenfels, & Vliet Vlieland, 2012	Acquired Brain Injury, Youth	G1: VR intervention	There was no significant difference in the results of the PedsQL completed by the participants following intervention. However, there was a significant improvement related to school functioning as reported by the parent-completed PedsQL.	Medium
SF-8 Health Survey (SF-8)	**Nintendo Wii:** *Wii Fit*	Chao, Scherer, Montgomery, Wu, & Lucke, 2015	Well Elderly, Assisted Living Facilities	G1: VR Intervention. G2: Health education sessions	There was no significant improvement in mental health-related quality of life as measure by the SF-8.	Medium
Social Provisions Scale	**Nintendo Wii:** Bowling	Bell, et al., 2011	Well Elderly, Assisted Living Facilities	G1: VR intervention and fall prevention class G2: VR activities only G3: No intervention	No significant difference was noted for any of the three groups overall. However, the researchers found significant differences on individual items of the assessment.	Medium
World Health Organization Quality of	**Nintendo Wii:** *Wii Sports:* Baseball,	Keogh, Power, Wooller,	Elderly, Residential Aged-care	G1: VR intervention G2: No	The VR group demonstrated a significant increase in the Psychological section of the	Medium

Standardized Tests	Use of Virtual technologies	Author, year	Population	Groups	Assertions/Outcomes	Level of evidence
Life (continued) **Questionnaire-Brief Australian version (WHOQOL-BREF)**	Boxing, Golf, Tennis, 10-pin bowling)	Lucas, & Whatman, 2014	Center	intervention	WHOQOL-BREF following the intervention period when compared to the control group.	
Category: Sensory integration/pain						
McGill Pain Questionnaire-Short Form	**Nintendo Wii:** *Wii Fit*	Yuen, Holthaus, Kamen, Sword, & Breland, 2011	Systemic Lupus Erythematosus, African American Women	G1: VR intervention	There was a significant improvement in the intensity of pain as measured by the Short-form of the McGill Pain Questionnaire.	Medium
Sensory Organization Test	**Xbox Kinect**	Ortiz-Gutiérrez, et al., 2013	Multiple Sclerosis	G1: telerehabilitation VR intervention G2: Standard physiotherapy	The VR group demonstrated a significant vestibular preference as measured by the SOT, and no significant difference regarding visual and somatosensory preference. The standard therapy group demonstrated a significant somatosensory preference only.	High
Test of Sensory Integration Function (TSIF)	Nintendo Wii	Wuang, Chaing, Su, &, Wang, 2011	Down Syndrome, Children	G1: VR intervention G2: Standard therapy G3: No intervention	The VR group demonstrated significantly greater results in all subtests of the Test of Sensory Integration Function, except for sensory discrimination, than the standard OT group and the control group.	High

Standardized Tests	**Use of Virtual technologies**	**Author, year**	**Population**	**Groups**	**Assertions/Outcomes**	**Level of evidence**
Category: Miscellaneous						
Global Performance (as measured by the Movement Assessment Battery for Children [M-ABC])	Nintendo Wii Fit Plus	Esposito, et al., 2013	Migraine without Aura, Children	G1: VR intervention for children with MoA G2: No intervention for typically developing children	The VR group demonstrated significant improvements in the global performance aspect of the mABC. There were no significant improvements in the control group.	High

Section 7: Case Scenarios

In order to facilitate understanding of effective evidence-based implementation of VR, the authors of this guide generated hypothetical case scenarios pertaining to the use of VR in OT. A case study has been created for each aspect of the domain of OT within the OTPF-3 (occupations, client factors, performance skills, performance patterns, context and environment), as well as for assessment tools (AOTA, 2014). Themes throughout the literature were used to apply similar principles within each case scenario to assist in applying evidence to practice. The case scenarios are for reflection purposes and to assist OT practitioners in understanding various ways to implement VR into therapy to address occupations, client factors, performance skills, performance patters, context and environment, and assessment tools.

Occupations

Case scenario. Phil, a 44 years old male, was diagnosed with Multiple Sclerosis (MS) 20 years ago. He recently received OT services in an outpatient rehabilitation setting following hospitalization from an exacerbation of his symptoms 4 weeks ago. During the evaluation process, he reported significant occupational deficits in social participation. Despite his MS, he has been involved in a bowling league for 10 years utilizing energy conservation techniques developed with OT to decrease fatigue. Following this last exacerbation of symptoms, it has become increasingly difficult for Phil to participate in the bowling leguae due to the mobility and endurance demands. Although the progression of his MS made it difficult for Phil to participate in physical activity for extended periods of time, Phil reported his goal was to be able to resume participation in the occupation bowling.

Intervention. Phil's OT practitioner utilized the Occupational Behavioral Model (Reilly, 1969) to promote change and motivation and to encourage participation in occupations. By using this model, the OT practitioner also integrated occupation into therapy and explored new strategies to promote success.

Phil and his OT practitioner developed an intervention plan to improve endurance for bowling and identified new strategies to promote social participation utilizing the *Exploration* concept of the Occupational Behavior Model (Reilly, 1969). Phil reported living near a community event center that hosts a community Wii bowling event. After incorporating Wii bowling into a therapy intervention to assure Phil's safety and *Competence* (Reilly, 1969), Phil participated in the community event.

Outcome. At the next therapy session, Phil reported *Achievement* as Wii bowling in the community was a motivating way to re-engage in an activity he thought he could no longer do (Reilly, 1969). The VR activity provided a new way for him to engage in social participation, as well as improve his physical abilities.

Figure 6. Phil completes Nintendo Wii Bowling to increase his endurance through remaining standing for prolonged periods of time. OT Practitioner guidance and grading of the activity ensures safety and competence prior to the community Wii bowling event.

Client Factors

Case scenario. William worked as a farm hand on a small dairy farm where he assisted in milking cows twice a day in addition to other physical labor. Three month ago, William experienced a traumatic brain injury from an accident on the farm. This TBI resulted in some neglect of his right arm, which caused a decrease his ability to complete purposeful movements and a decrease in his right arm strength. At this three month time period, William demonstrated the ability to lift his right arm against gravity independently, and had regained shoulder flexion to 110˚, abduction to 30˚, and horizontal adduction to 30˚. Following evaluation in the outpatient clinic, the OT practitioner concluded that William would benefit from skilled OT to increase this strength and further address his ability to produce controlled movements.

Intervention. Due to the need to grade activities and utilize repetitious movements to encourage arm strengthening, muscle endurance, and controlled movements, William's OT practitioner utilized the Biomechanical frame of reference.

Utilizing the research of Lee (2013), and Rand, Givon, Weingarden, Nota, and Zeillig (2014) William's OT practitioner suggested using the Xbox Kinect as an intervention strategy, as it encourages purposeful movements and arm use through an engaging activity. In later sessions, William's therapist also graded the activity through adding resistance by using therabands to further strengthen his right arm during the Xbox activities (Figure 7).

Outcome. Through repeated engagement in the Xbox Kinect activities throughout several sessions, William and his therapist were able to increase his arm coordination and strength while also participating in engaging activities within the safe environment of the clinic. William demonstrated an increase in purposeful movements and achieved near complete recovery of his coordination. Due to his progress, the use of therabands during the Xbox activity graded the strengthening demands required of him. Through combining skilled OT with the Xbox Kinect, the OT practitioner was able to address the client factors of purposeful movements and arm strength in new and engaging ways.

Figure 7. *William participates Xbox Kinect 10,000 Leaks with skilled instruction and guidance from his OT practitioner. Grading of the activity is completed through safely applying therabands to add more resistance to the activity.*

Performance Skills

Case scenario. James, 31, worked as a shopkeeper for a construction company and obtained an injury to his left elbow after trying to stop a large box of tools from falling. Due to his pain, James had not been using this arm as often, as he is right-handed, and demonstrated atrophy primarily in his dorsal forearm. James finally sought medical attention and discovered he had torn his extensor digitorum longus tendon near the elbow, which has since been repaired. James participated in therapy throughout treatment and it was confirmed by his doctor he was safe to begin strengthening in order to complete his job duties of lifting and sorting a variety of tools. However, James demonstrated inconsistencies in completing his home-based strengthening program.

Intervention. Due to James's lack of motivation to participate in the home program, the OT practitioner decided to apply the Model of Human Occupation (MOHO; Keilhofner & Burke, 1980). The MOHO supported the OT practitioner's ability to focus on what motivates James, and determine what interventions would be the right *Fit* to use with James (Keilhofner & Burke, 1980).

While completing the Interest Checklist (Keilhofner & Neville, 1983) James's OT practitioner learned that James lives with his girlfriend and 2 other roommates and that they frequently use the Xbox Kinect. James and his therapist collaborated and agreed James would be more likely to complete his home program if it involved more activity-based exercise, such as the Xbox Kinect. The OT Practitioner provided James with a series of stretches for warm up and strengthening techniques. In addition, the OT Practitioner provides James with wrist weights to wear while participating in Xbox Kinect activities with his roommates for 30 minutes each day.

Outcome. Due to the OT practitioner utilizing one of James's frequent and favored activities as a home-based program, James reported good adherence to therapeutic recommendations and demonstrated significant improvements in his performance skill of lifting and manipulating tools of various weights. He also stated that his roommates and girlfriend frequently challenged him and he performs more than the recommended time for the activity.

Figure 8. James uses a motivating activity to address his performance skill deficits of manipulating various tools. The Xbox Kinect provides a meaningful strategy to strengthen his arm and increase his coordination and controlled movements.

Performance Patterns

Case scenario. Jean, a 56-year-old female, was recovering from a left CVA that occurred two months ago. She had been living with her sister since her stroke, who was able to assist Jean as needed. Together, they babysat for Jean's daughter and watched her two children for an evening once a week. Jean demonstrated near full recovery of her physical abilities except for her right arm; however, she still displayed some minimal cognitive deficits including impaired way finding and orientation skills. However, the main concern for Jean was her performance patterns, including her routine of morning exercise, and her role of being a grandmother. Due to her cognitive impairments, Jean had been unable to continue to participate in her morning routine of walking on a nearby road and stated that she felt "lazy not exercising like before."

Intervention. Jean's OT Practitioner utilized the Person Environment Occupation Model (PEO), as it allowed her to address Jean, her environment, and her desired occupations as they influence occupational performance (Law et al., 1996). Through addressing the fit between Jean's skills and abilities, her desire to participate in lost occupations, and her interaction with the environment, the OT practitioner could better promote Jean's participation in her performance patterns of caregiving for her grandchildren and exercising (Law et al., 1996).

Jean's OT practitioner discussed various options with her and discovered Jean's grandchildren enjoy using the Nintendo Wii during their weekly visits. Jean's agreed to "give it a try " and the OT practitioner analyzed various Nintendo Wii games available for her to use. Together they identified specific games to promote endurance and arm use, such as Boxing and Tennis. The OT practitioner also provided and discussed a handout instructing Jean and her sister in how Jean can complete stretching prior to participating in the activity that will help to restore her lost occupations of caregiving and exercise.

Outcome. The next week, Jean reported success and stated, "We played the Wii for about an hour last time they came over and had a lot of fun! I've also been using it in the morning as exercise, just like you recommended." Not only has participation in Nintendo Wii activities assisted Jean in adding exercise to her daily routine again, it has also helped increase her interactions with her grandchildren and have helped Jean to fulfill her role as a grandmother.

Figure 9. Jean participates in Nintendo Wii Boxing with her granddaughter after completing PNF stretching to promote her ability to fulfill her roles of being an individual who exercises and being a grandmother.

Context and Environment

Case scenario. Brandon, an OT practitioner at an inpatient mental health hospital, works with individuals with a variety of mental illnesses including schizophrenia, depression, and personality disorders. The current patient population had been complaining that they were not able to participate in a larger variety of physical activities, as they only had access to a small courtyard. Many of the individuals also simply sat around between groups not participating in any activities and, as a result, have gained weight.

Intervention. Brandon recognized this as a prime opportunity to integrate the Ecology of Human Performance Model, as it addresses focusing on the environment as a key component that encourages occupational participation (Dunn, Brown, & McGuigan, 1994). Through changing the environment, Brandon could promote the patients' ability to participate in a greater *performance range* of tasks and activities (Dunn, Brown, & McGuigan, 1994).

Following a review of current literature, Brandon concluded that by obtaining a Nintendo Wii and Xbox Kinect, he would be able to provide individuals at the facility with a greater range of available activities that produce light exercise (Robert, Ballaz, Hart, & Lemay, 2013; Taylor, et al., 2012), promote enjoyment (Howcroft, et al., 2012; Nicholson, McKean, Lowe, Fawcett, & Burkett, 2015; Yohanna, et al., 2011), increase general health (Lee, Son, Kim, & Yoon, 2015; Park, Lee, & Ko, 2013), may help individuals to lose weight (Yuen, Holthaus, Kamen, Sword, & Breland, 2011), and are safe to use (Pompeu, et al., 2014). He also considered precautions for doing these activities. Because psychiatric medications have side effects such as orthostatic hypotension and dizziness, he had some stable parallel bars placed by the television and VR equipment so that patients could use the bars for stability. He provided individualized therapy for each patient prior to using the VR and bars to assure safety during use. After training on the equipment, they were free to use the VR and bars independently.

Outcome. Following the purchase of the VR systems and their integration into the Unit activities, Brandon utilized a simple anonymous survey to measure the success of the VR systems in meeting the needs of the patient population. Improvements that were noted by the patients included enjoyment of the new range of activities, more active participation in physical activities, an increase in socializing with peers on the unit, and an increase in positive interactions with staff.

Figure 10. Brandon and two of the patients at the mental health unit participate in the new VR activities to increase their physical activity.

Assessment Tools

Case scenario. Dennis experienced hemiparesis following a stroke 3 days ago and has since been transferred to the acute rehab floor of a small town hospital. This hospital utilizes the Fugle-Meyer Assessment (FMA) for all of its patients in stroke rehabilitation (Fugle-Meyer, Jaasko, Leyman, Olsson, & Steglind, 1975). Dennis presented with impaired balance, however, was able to walk with minimal assistance if using a front-wheeled walker. He also presented with limited coordination and control of his right arm, but was able to adequately hold and advance the walker with the right hand. While he demonstrated the ability to perform functional tasks, such as using his right arm as an assist to open toothpaste or put on a coat, the amount of time required to complete these activities nearly doubled from prior to his stroke.

Intervention. Due to his primary deficits being balance and coordination, the OT practitioner utilized the Task-Oriented approach to Motor Learning (Shumway-Cook & Woollacott, 2001). This approach utilized typical motor learning strategies in addition to using specific tasks that require the desired action to be learned.

Dennis voiced his desire to participate in using the Nintendo Wii, as he had heard of it being used in the hospital and had also recently began playing it with his grandchildren. After examining the current research, the OT practitioner acknowledged use of the Wii as a potential rehabilitation tool that also has been described to improve the results identified in the FMA (Chen, et al., 2014; Choi, et al., 2014; Joo, et al., 2010; Rand, et al., 2014; Shiner, Byblow, & McNulty, 2014; Sin and Lee, 2013). As outlined by current research, the OT practitioner utilized the Nintendo Wii in addition to traditional OT stroke protocols for coordination to increase Dennis's functional ability as well as use his desired treatment method. Through using Nintendo Wii activities, such as tennis, bowling, and golf, the therapist was able to grade the movements according to Dennis's progress. The therapist also addressed his balance by having Dennis complete activities while standing with the walker nearby and while she held his gait belt, or by having him perform activities while sitting on a therapy ball.

Outcome. Following the repeated therapeutic use of the Nintendo Wii as an intervention, Dennis began to demonstrate improvements in his balance and his controlled moments of his right arm. These improvements were clearly noticeable on Fugle-Meyer Assessment results at his time of discharge.

Figure 11. The Nintendo Wii Golf activity was utilized by Dennis to promote right arm movements while he uses his left arm as support

Summary

Discussion

New technology, including VR, is being increasingly incorporated into daily activity. The Nintendo Wii and Xbox Kinect are examples of consumer VR products that are affordable, accessible, and feasible for use by the public and as a treatment modality by OT practitioners. VR is both a context in which treatment can take place, and a treatment modality requiring evidence-based support for its use (AOTA, 2014). Glegg et al., (2013), listed a lack of time and lack of knowledge as the most reported barriers to OT practitioners' use of VR, decreasing practitioner self-efficacy with VR use.

Despite the presence of more than 2,000 VR-related articles, there is a lack of literature organizing this evidence to guide therapists in clinical use of VR (Levac & Miller, 2013; Proffitt & Lange, 2015). This evidence-based guide was created utilizing the OTPF-3 as a theoretical framework (AOTA, 2014). The aspects of the OTPF-3 were utilized to create sections of the guide containing data from research articles pertaining to occupations, client factors, performance skills, performance patterns, context and environment, and the assessment tools used to measure the treatment outcomes. An additional section of case scenarios was created to provide examples of how to utilize the guide within practice. It is recommended that OT practitioners utilize this guide to locate current evidence supporting positive outcomes in utilizing VR as a treatment modality.

Implications

This product, *Virtual Reality: An Evidence-Based Guide for Occupational Therapy,* will benefit OT practitioners in providing a guide to the research regarding effective implementation of VR systems including the Nintendo Wii and Xbox Kinect. These two VR systems are accessible, feasible, and common technology available to the public. The authors of this guide found themes in the evidence for positive outcomes related to motivation, social interaction, and movement based outcomes. However, the practitioner will continue to need clinical reasoning skills to appropriately match the use of VR technology to the client. It is recommended that OT practitioners implement this guide with the various populations and settings reflected in the literature. Methods for marketing this guide to OT practitioners include publishing the guide, providing an accessible portable document format (PDF), or creating a website to display the organized evidence. OT practice would benefit from continued research and data guiding positive outcomes and evidence-based practice with VR use.

Limitations

Limitations for this product include the exclusion of alternative VR methods such as the iPad or third party software products. As VR changes and evolves, this new technology will require continuous research supporting its feasibility, safety, ethical concerns, and treatment outcomes. Despite supporting evidence, VR may not be an effective modality for all clients due to client preferences and perceptions of VR (Laver, Ratcliffe, George, Lester, & Crotty, 2013). While this product incorporates the OTPF-3 as a theoretical framework, additional models were not incorporated into the design of this guide due to the wide variety of populations and settings where this guide may be used. In addition, the OTPF-3 is the unifying conceptual model for OT practice. (AOTA, 2014)

Recommendations

With the current state of evidence, it is important that VR continues to be recognized as a context in which therapy takes place and not just an intervention alone (AOTA, 2014). The clinical reasoning of the OT practitioner remains critical to the effective fit of VR as a treatment modality with the aspects of the client addressed in the OTPF-3 (AOTA, 2014; Salem et al., 2012). VR systems such as the Nintendo Wii and Xbox Kinect have potential to be incorporated into effective home-based therapeutic activities. However, research is limited on the effect of these VR systems on adherence and efficacy in the home. This product would be an effective tool for clinical practice if it does not remain static, but is improved upon as evidence and technology changes. A follow-up qualitative study identifying barriers and benefits of this product is recommended.

The *Virtual Reality: An Evidence-Based Guide for Occupational Therapy* was created to assist the OT practitioner in implementing effective use of VR as a treatment modality and a context. A large body of literature exists regarding VR systems being used with a variety of populations and settings to promote positive outcomes, yet a lack of knowledge and a lack of organization of this literature inhibits OT practitioners from using VR. An extensive literature review was conducted regarding the use of two VR systems, the Nintendo Wii and Xbox Kinect, due to the availability and accessibility of these systems. The OTPF-3 (AOTA, 2014) was used to guide the organization of evidence retrieved due to the wide variety of populations and settings where VR can be used. By implementing this resource in clinical settings reflected in the literature, OT practitioners may have an organized way to guide intervention utilizing VR for positive outcomes such as motivation, movement-related functions, and social participation.

References

American Occupational Therapy Association. (2014). Occupational therapy practice framework: Domain and process (3rd ed.). *American Journal of Occupational Therapy, 68*(Suppl. 1), S1– S48. http://dx.doi.org/10.5014/ajot.2014.682006

AlSaif, A. A., & Alsenany, S. (2015). Effects of interactive games on motor performance in children with spastic cerebral palsy. *Journal of Physical Therapy Science 27*(6), 2001-2003. doi: 10.1589/jpts.27.2001

Bacon, N., Farnworth, L., & Boyd, R. (2012). The use of Wii Fit in forensic mental health" exercise for people at risk of obesity. *British Journal of Occupational Therapy, 75*(2), 61-68. doi:10.4276/030802212X13286281650992

Bainbridge, E., Bevans, S., Keeley, B., & Oriel, K. (2011). The effects of the Nintendo Wii Fit on community-dwelling older adults with perceived balance deficits: A pilot study. *Physical & Occupational Therapy in Geriatrics 29*(2), 126-135. doi: 10.3109/02703181.2011.569053

Bell, C. S., Fain, E., Daub, J., Warren, S. H., Howell, S. H., Southard, K. S., Sellers, C., & Shadoin, H. (2011). Effects of Nintendo Wii on quality of life, social relationships, and confidence to prevent falls. *Physical & Occupational Therapy in Geriatrics, 29*(3), 213-221. doi:10.3109/02703181.2011.559307

Berg, P., Becker, T., Martian, A., Primrose, K. D., & Wingen, J. (2012). Motor control outcomes following Nintendo Wii use by a child with Down Syndrome. *Pediatric Physical Therapy, 24*(1), 78-84. doi: 10.1097/PEP.0b013e31823e05e6.

Bieryla, K. A., & Dold, N. M. (2013). Feasibility of Wii Fit Training to improve clinical measures of balance in older adults. *Journal of Clinical Interventions in Aging, 8,* 775-781. doi: 10.2147/CIA.S46164

Celinder, D. and Peoples, H. (2012). Stroke patients’ experiences with Wii Sports during inpatient rehabilitation. *Scandinavian Journal of Occupational Therapy 19*(5) 457-463. doi: 10.3109/11038128.2012.655307

Chao, Y., Scherer, Y. K., Montgomery, C. A., Wu, Y., & Lucke, K. T. (2015). Physical and psychosocial effects of Wii Fit exergames use in assisted living residents: A pilot study. *Clinical Nursing Research, 24*(6), 589-603. doi: 10.1177/1054773814562880.

Chao, Y., Scherer, Y. K., Wu, Y., Lucke, K. T., & Montgomery, C. A. (2013). The feasibility of an intervention combining self-efficacy theory and Wii Fit exergames in assisted living residents: A pilot study. *Geriatric Nursing 34*(5), 377-382. doi: 10.1016/j.gerinurse.2013.05.006.

Chen, M., Huang, L., Lee, C., Hsieh, C, Lin, Y., Lui, H., Lu, W. (2014) A controlled pilot trial of two commercial video games for rehabilitation of arm function after stroke. *Clinical Rehabilitation 28*(10), doi: 10.1177/0269215514554115

Cho, K. H., Lee, K. J., & Song, C. H. (2012). Virtual-reality balance training with a video-game system improves dynamic balance in chronic stroke patients. *The Tohoku Journal of Experimental Medicine, 228*(1), 69-74.

Choi, J., Han, E., Kim, B., Kim, S., Im, S., Lee, S., Hyun, C. (2014) Effectiveness of commercial gaming-based virtual reality movement therapy on functional recovery of upper extremity in subacute stroke patients. *Annals of Rehabilitation Medicine. 38*(4), 485-493. doi: 10.5535/arm.2014.38.4.485

Cole, M. B. & Tufano, R. (2008). Applied theories in occupational therapy: A practical approach. Thorofare, NJ: Slack Inc.

De Kloet, A. J., Berger, M. A., Verhoeven, I. M., Van Stein Callenfels, K., & Vliet Vlieland, T. P. (2012) Gaming supports youth with acquired brain injury? A pilot study. *Brain Injury, 26*(7-8), 1021-1029. doi: 10.3109/02699052.2012.654592.

Deutsch, J. E., Myslinski, M. J., Kafri, M., Ranky, R., Sivak, M., Mavroidis, C., & Lewis, J. A. (2013). Feasibility of virtual reality augmented cycling for health promotion of people poststroke. *Journal of Neurologic Physical Therapy, 37*(3), 118-124. doi:10.1097/NPT.0b013e3182a0a078

Dunn, W., Brown, C., McGuiga, A. (1994). The ecology of human performance: A framework for considering the effect of context. *American Journal of Occupational Therapy, 48*, 595-607.

Esposito, M., Ruberto, M., Gimigliano, F., Marotta, R., Gallai, B., Parisi, L., Levano, S. M., Roccella, M., & Carotenuto, M. (2013). Effectiveness and safety on Nintendo Wii Fit Plus training in children with migraine without aura: A preliminary study. *Journal of Neuropsychiatric Disease and Treatment, 9,* 1803-1810. doi: 10.2147/NDT.S53853.

Fan, S., Su, F., Chen, S., Hou, W., Sun, J., Chen, K., Lin, W., & Hsu, S. (2014). Improved intrinsic motivation and muscle activation patterns in reaching task using virtual reality training for stroke rehabilitation: A pilot randomized control trial. *Journal of Medical and Biological Engineering, 23*(4), 399-407.

Ferguson, G. D., Jelsma, D., Jelsma, J., & Smits-Englesman, B. C. M. (2013). The efficacy of two task-oriented interventions for children with Developmental Coordination Disorder: Neuromotor Task Training and Nintendo Wii Fit training. *Research in Developmental Disabilities, 34*(9), 2449-2461. doi: 10.1016/j.ridd.2013.05.007

Forsberg, A., Nilsaga, Y., & Boström, K. (2015). Perceptions of using videogames in rehabilitation: A dual perspective of people with multiple sclerosis and physiotherapists. *Disability and Rehabilitation, 37*(4), 338-344. doi: 10.3109/09638288.2014.918196.

Fugl-Meyer AR., Jaasko L., Leyman I., Olsson, S., & Steglind, S. (1975). The post- stroke hemiplegic patient. 1. a method for evaluation of physical performance. *Scandinavian Journal of Rehabilitation Medicine*, *7*(1), 13–31.

Fung, V., Ho, A., Shaffer, J., Chung, E., & Gomez, M. (2012). Use of Nintendo Wii Fit in the rehabilitation of outpatients following total knee replacement: A preliminary randomized control trial. *Physiotherapy, 98*(3), 183-188. doi: 10.1016/j.physio.2012.04.001.

Glegg, S. M. N., Holsti, L., Velikonja, D., Ansley, B., Brum, C., Sartor, D. (2013). Factors influencing therapists' adoption of virtual reality for brain injury rehabilitation. Cyberpyscyhology, Behavior, and Social Networking, 16(5), 385-401 doi: 10.1089/cyber.2013.1506

Gutiérrez, R. O., Galán del Río, F., Cano de la Cuerda, R., Alguacil Diego, I. M., González, R. A., & Page, J. M. (2013). A telerehabilitation program by virtual reality video games improves balance and postural control in multiple sclerosis patients. *Neurorehabilitation, 33*(4), 545-554. doi:10.3233/NRE-130995

Hammond, J., Jones, V., Hill, E. L., Green, D., & Male, I. (2012). An investigation of the impact of regular use of the Wii Fit to improve motor and psychosocial outcomes in children with movement difficulties: A pilot study. *Child: Care, Health and Development, 40*(2), 165-175. doi:10.1111/cch.12029

Herz, N. B., Mehta, S. H., Sethi, K. D., Jackson, P., Hall, P., & Morgan, J. C. (2013). Nintendo Wii rehabilitation (Wii-hab) provides benefits in Parkinson's disease. *Parkinsonism & Related Disorders, 19*(11), 1039-1042. doi: 10.1016/j.parkreldis.2013.07.014.

Holmes, J. D., Gu, M. L., Johnson, A. M., & Jenkins, M. E., (2013). The effects of a home-based virtual reality rehabilitation program on balance among individuals with Parkinson's disease. *Physical & Occupational Therapy in Geriatrics, 31*(3), 241-253. doi: 10.3109/02703181.2013.814743

Howcroft, J., Klejman, S., Fehlings, D., Wright, V., Zabjek, K., Andrysek, J., & Biddiss, E. (2012). Active video game play in children with cerebral palsy: Potential for physical activity promotion and rehabilitation therapies. *Archives of Physical Medicine and Rehabilitation, 93*(8), 1448-1456. doi: 10.1016/j.apmr.2012.02.033.

Imam, B., Miller, W. C., McLaren, L., Chapman, P., & Finlayson, H. (2013). Feasibility of the Nintendo Wii Fit for improving walking in individuals with a lower limb amputation. *SAGE Open Medicine, 3*(1), 1-11. doi:10.1177/2050312113497942

Janssen, J., Verschuren, O., Levac, D., Eemers, J., & Ketelaar, M. (2012). Structured game-related group therapy for an adolescent with Acquired Brain Injury: A case report. *Journal of Pediatric Rehabilitation Medicine: An Interdisciplinary Approach, 5*(2), 125-132. doi: 10.3233/PRM-2012-0204

Joo, L. Y., Yin, T. S., Xu, D., Thia, E., Chia, P. F., Kuah, C. W. K., & He, K. K. (2010). A feasibility study using interactive commercial off-the-shelf computer gaming in upper limb rehabilitation in patients after stroke. *Journal of Rehabilitation Medicine, 42*(5) 437-441. doi: 10.2340/16501977-0528.

Keilhofner, G., & Burke, J. (1980) A model of human occupation, part one. Conceptual framework and content. *American Journal of Occupational Therapy, 34,* 572-581.

Keilhofner, G., & Neville, A (1983), *The modified Interest Checklist.* Unpublished assessment, University of Illinois at Chicago.

Keogh, J. W. L., Power, N., Wooller, L., Lucas, P., & Whatman, C. (2014). Physical and psychosocial function in residential aged-care elders: Effects of Nintendo Wii Sports games. *Journal of Aging and Physical Activity 22*(2), 235-244. doi: 10.1123/japa.2012-0272.

Laver, K., Ratcliffe, J., George, S., Lester, L., & Crotty, M. (2013). Preferences for rehabilitation service delivery: A comparison of the views of patients, occupational therapists and other rehabilitation clinicians using a discrete choice experiment. Australian Occupational Therapy Journal, 60(2), 93-100 8p. doi: 10.1111/1440-1630.12018

Law M, Cooper B, Strong S, Stewart D, Rigby P, Letts L. (1996). The Person-Environment-Occupational Model: A transactive approach to occupational performance. *Canadian Journal of Occupational Therapy 63*(1), 9-23.

Lee, GC. (2013). Effects of training using video games on the muscle strength, muscle tone, and activities of daily living of chronic stroke patients. *Journal of Physical Therapy Science, 25*(5), 595-597. doi: 10.1589/jpts.25.595

Lee, M., Son, J., Kim, J., & Yoon, BC. (2015). Individualized feedback-based virtual reality exercise improves older women's self-perceived health: A randomized controlled trial. *Archives of gerontology and Geriatrics, 61*(2) 154-160. doi: 10.1016/j.archger.2015.06.010.

Levac, D. E., & Miller, P. A. (2013). Integrating virtual reality video games into practice: Clinicians' experiences. Physiotherapy Theory & Practice, 29(7), 504-512. doi:10.3109/09593985.2012.762078

Luna-Oliva, L., Ortiz-Gutiérrez, R. M., Cano-de la Cuerda, R., Piédrola, R. M., AlguacilDiego, I. M., Sánchez-Camarero, C., & Martínez Culebras, M. C. (2013). Kinect Xbox 360 as a therapeutic modality for children with cerebral palsy in a school environment: A preliminary study. *Neurorehabilitation, 33*(4), 513-521. doi:10.3233/NRE-131001

McClanachan, N. J., Gesch, J., Wuthapanich, N., Flemin, J., & Kuys, S. S. (2013). Feasibility of gaming console exercise and its effect on endurance, gait and balance in people with an acquired brain injury. *Brain Injury, 27*(12), 1402-1408. doi: 10.3109/02699052.2013.823654

Mombarg, R., Jelsma, D., & Hartman, E. (2013). Effect of Wii-intervention on balance of children with poor motor performance. *Research in Developmental Disabilities, 34*(9), 2996-3003. doi: 10.1016/j.ridd.2013.06.008.

Nam-Yong, L., Dong-Kyu, L., & Hyun-Seung, S. (2015). Effect of virtual reality dance exercise on the balance, activities of daily living, and depressive disorder status of Parkinson's disease patients. *Journal of Physical Therapy Science, 27*(1), 145-147. doi:10.1589/jpts.27.14

Nicholson, V. P., McKean, M., Lowe, J., Fawcett, C., & Burkett, B. (2015). Six weeks of unsupervised Nintendo Wii Fit gaming is effective at improving balance in independent older adults. *Journal of Aging and Physical Activity, 23*(1), 153-158. doi: 10.1123/japa.2013-0148.

Ortiz-Gutiérrez, R., Cano-de la Cuerda, R., Galán Del Río, F., Alguacil-Diego, I. M., Palacios-Ceña, D., & Miangolarra-Page, J. C. (2013**).** A telerehabilitation program improves postural control in Multiple Sclerosis patients: A Spanish preliminary study. *International Journal of Environmental Research and Public Health, 10*(11), 5697-5710. doi: 10.3390/ijerph10115697

Owen, S. G., Garne, J. C., Mark Loftin, J., Van Blerk, N., & Ermi, K. (2011). Changes in physical activity and fitness after 3 months of home Wii Fit use. *Journal of Strength and Conditioning Research, 25*(11), 3191-3197. doi: 10.1519/JSC.0b013e3182132d55

Paquin, K., Ali, S., Carr, K., Crawley, J., McGowan, C., & Horton, S. (2015). Effectiveness of commercial video gaming on fine motor control in chronic stroke within community-level rehabilitation. *Disability and Rehabilitation, 37*(23), 2184-2191. doi: 10.3109/09638288.2014.1002574.

Park, E., Kim, S., & Lee, C. (2015). The effects of virtual reality game exercise on balance and gait in the elderly. *Journal of Physical Therapy Science, 27*(4), 1157-1159.

Park, J., Lee, S., Ko, D. (2013) The effects of the Nintendo Wii exercise program on chronic work-related low back pain in industrial workers. *Journal of Physical Therapy Science, 25*(8), 985-988. doi:10.1589/jpts.25.985

Parry, I., Carbullido, C., Kawada, J., Bagley, A., Sen, S., Greenhalgh, D., & Palmieri, T. (2014). Keeping up with video game technology: Objective analysis of Xbox Kinect and PlayStation 3 Move for use in burn rehabilitation. *Burns,* 40(5), 852-859. doi: 10.1016/j.burns.2013.11.005.

Pompeu, J. E., Arduini, L. A., Botelho, A. R., Fonseca, M. B. F., Pompeu, S. M. A. A. Torriani-Pasin, C., & Deutsch, J. E. (2014). Feasibility, safety and outcomes of playing Kinect Adventures! People for people with Parkinson's disease: A pilot study. *Physiotherapy, 100*(2), 162-168. doi: 10.1016/j.physio.2013.10.003.

Prata, M. G., & Scheider, M. E. (2014). Effects of strength and balance training on the mobility, fear of falling and grip strength of elderly female fallers. *Journal of Bodywork & Movement Therapies, 19*(4), 646-650. doi: 10.1016/j.jbmt.2014.11.013.

Proffitt, R., & Lange, B. (2015). Considerations in the efficacy and effectiveness of virtual reality interventions for stroke rehabilitation: Moving the field forward. Physical Therapy, 95(3), 441-448. doi:10.2522/ptj.20130571

Rand, D., Givon, N., Weingarden, H., Nota, A., & Zeilig, G., (2014). Eliciting upper extremity purposeful movements using video games: A comparison with traditional therapy for stroke rehabilitation. *Neurorehabilitation and Neural Repair, 28*(8), 733-739. doi: 10.1177/1545968314521008.

Reilly, M. (1969. The educational process. *American Journal of Occupational Therapy, 26*, 169-172.

Robert, M., Ballaz, L., Hart, R., & Lemay, M. (2013). Exercise intensity levels in children with cerebral palsy while playing with an active video game console. *Physical Therapy, 93*(8), 1084-1092. doi: 10.2522/ptj.20120204.

Roopchand-Martin, S., Nelson, G., Gordon, C., & Sing, S. Y. (2015). A pilot study using the Xbox Kinect for exercise conditioning in sedentary female university students. *Technology and Health Care, 23*(3), 275-283. doi: 10.3233/THC-150899.

Rowland, J. L. & Rimmer, J. H. (2012). Feasibility of using active video gaming as a means for increasing energy expenditure in three nonambulatory young adults with disabilities. *Physical Medicine and Rehabilitation, 4*(8), 569-573. doi: 10.1016/j.pmrj.2012.03.011.

Sackett, Rosenberg, Gray, Haynes, and Richardson (1996). Evidence based medicine: What it is and what it isn’s. *British Medical Journal, 312*, 71-72

Salem, Y., Gropack, S., Coffin, D., and Godwin, E. (2012). Effectiveness of a low-cost virtual reality system for children with developmental delay: a preliminary randomized single-blind controlled trial. *Physiotherapy 98*(3), 189-195. doi: http://dx.doi.org/10.1016/j.physio.2012.06.003

Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., Thorpe, K., Cohen, L., & Bayley, M. (2010). Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation. *Stroke 41*(7), 1477-84. doi: 10.1161/STROKEAHA.110.584979

Shih, C., Wang, S., Chang, M., &, Shih, C. (2012). Enabling people with developmental disabilities to actively perform designated occupational activities according to simple instructions with a Nintendo Wii Remote Controller by controlling environmental stimulation. *Research in Developmental Disabilities 33*(4) 1194-1199. doi: 10.1016/j.ridd.2012.02.008.

Shih, C., Wang, S., & Wang, Y. (2014). Assisting children with Attention Deficit Hyperactivity Disorder to reduce the hyperactive behavior of arbitrary standing in class with a Nintendo Wii Remote Controller through an active reminder and preferred reward stimulation. *Research in Developmental Disorders, 35*(9), 2069-2076. doi: 10.1016/j.ridd.2014.05.007.

Shih, C., Yeh, J., Shih, C., & Chang, M. (2011). Assisting children with Attention Deficit Hyperactivity Disorder activity reduces limb hyperactive behavior with a Nintendo Wii Remote Controller through controlling environmental stimulation. *Research in Developmental Disabilities 32*(5), 1631-1637. doi: 10.1016/j.ridd.2011.02.014.

Shin, J., Song, G., & Hwangbo, G. (2015). Effects of conventional neurological treatment and virtual reality training program on eye-hand coordination in children with cerebral palsy. *Journal of Physical Therapy Science, 27*(7), 2151-2015. doi: 10.1589/jpts.27.2151.

Shiner, C. T., Byblow, W. D., & McNulty, P. A. (2014). Bilateral primary before Wii-based movement therapy enhances upper limb rehabilitation and its retention after stroke: A case-controlled study. *Neurorehabilitation and Neural Repair, 28*(9), 828-838. doi: 10.1177/1545968314523679

Shumway-Cook, A., & Woollacott, M. (2001). Motor control: Theory and practical applications 2nd ed.). Philadelphia, PA: Lippincott Williams & Wilkins.

Sin, HH, & Lee, GC. (2013). Additional virtual reality training using Xbox Kinect in stroke survivors with hemiplegia. *American Journal of Physical Medicine and Rehabilitation, 92*(10), 871-880. doi: 10.1097/PHM.0b013e3182a38e40.

Subramaniam, S., Hui-Chan, C., & Bhatt, T. (2014). A cognitive-balance control training paradigm using Wii Fit to reduce fall risk in chronic stroke survivors. *Journal of Neurological Physical Therapy, 38*(4), 216-25. doi: 10.1097/NPT.0000000000000056.

Tatla, S. K., Radomski, A., Cheung, J., Maron, M., & Jarus, T. (2014). Wii-habilitation as balance therapy for children with acquired brain injury. *Developmental Neurorehabilitation, 17*(1), 1-15. doi: 10.3109/17518423.2012.740508.

Taylor, L. M., Maddison, R., Pfaeffli, L. A., Rawstorn, J. C., Gant, N., & Kerse, N. K. (2012). Activity and energy expenditure in older people playing active video games. *Archives of Physical Medicine and Rehabilitation, 93*(12), 2281-2286. doi: 10.1016/j.apmr.2012.03.034.

Thompson-Butel, A. G., Lin, G., Shnier, C. T., & McNulty, P. A. (2015). Comparison of three tools to measure improvements in upper-limb function with poststroke therapy. *Neurorehabilitation and Neural Repair, 29*(4), 341-348. doi: 10.1177/1545968314547766.

Turpin, M. & Iwama, M. (2011). Using occupational therapy models in practice: A field guide. Edinburgh, UK: Elsevier.

Vernadakis, N., Derri, V., Tsitskari, E., & Antoniou, P. (2014). The effect of Xbox Kinect intervention on balance ability for previously injured young competitive male athletes: A preliminary study. *Physical Therapy in Sport, 15*(3), 148-155. doi: 10.1016/j.ptsp.2013.08.004.

Williams, B., Doherty, N., Bender, A., Mattox, H., & Tibbs, J. (2011). The effect of Nintendo Wii on balance: A pilot study supporting the use of the Wii in occupational therapy for the well elderly. *Occupational Therapy in Health Care, 25*(2-3), 131-139. doi: 10.3109/07380577.2011.560627

Wingham, J., Adie, K., Turner, D., Schofield, C., & Pritchard, C. (2015). Participant and caregiver experience of the Nintendo Wii Sports after stroke: Qualitative study of the trial of Wii in stroke (TWIST). *Clinical Rehabilitation, 29*(3), 295-305, doi: 10.1177/0269215514542638

Winkels, D. G. M., Kottink, A. I. R., Temmink, R. A. J., Nijlant, J. M. M., & Buurke, J. H. (2013). Wii-habilitation of upper extremity function in children with Cerebral Palsy. An exploratory study. *Developmental Neurorehabilitation, 16*(1), 44-51. doi: 10.3109/17518423.2012.713401.

Wollershein, D., Merkes, M., Shields, N., Liamputtong, P., Wallis, L., Reynolds, F., & Koh, L. (2010). Physical and psychosocial effects of Wii video game use among older women. *International Journal of Emerging Technologies and Society, 8*(2), 85-98.

Wuang, Y., Chaing C., Su, C., &, Wang, C. (2011). Effectiveness of virtual reality using Wii gaming technology in children with Down syndrome. *Research in Developmental Disabilities, 32*(1), 312-321. doi: 10.1016/j.ridd.2010.10.002.

Yohanna, S. K., Tufaro, P. A., Hunter, H., Orleman, L., Palmatier, S., Sang, C., Gorga, D. I., & Yurt, R. W. (2011). The utilization of Nintendo Wii during burn rehabilitation: A pilot study. *Journal of Burn Care & Research, 33*(1), 36-45. doi: 10.1097/BCR.0b013e318234d8ef

Yuen, H., Holthaus, K., Kamen, D., Sword, D., & Breland, H. (2011**).** Using Wii Fit to reduce fatigue among African American women with systemic lupus erythematous: A pilot study. *Lupus, 20*(12), 1293-1299. doi: 10.1177/0961203311412098.

Yuen, H. K., Wang, E., Holthaus, K., Vogtle, L. K., Sword, D., Breland, H. L., & Kamen, D. L. (2013). Self-reported versus objectively assessed exercise adherence. *The American Journal of Occupational Therapy, 67*(4), 484-489. doi: 10.5014/ajot.2013.007575.

APPENDIX B

PHOTO RELEASE FORMS

Photography Release Form

Date: 4-14-16

I am (Circle one): [✓ *Subject*] *Parent/Legal Guardian*

I, Arnie Nelson hereby grant permission to the
(Please Print)

students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

Printed Name *Signature* / / *Date*

[✓ Participant/guardian:]

Arnie Nelson *Printed Name* Arni Nelson *Signature* 4/14/2016 *Date*

Photography Release Form

Date: 4-13-16

I am (Circle one): [✓ *Subject*] *Parent/Legal Guardian*

I, Kiplyn Nelson hereby grant permission to the
(Please Print)

students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

		/ /
Printed Name	*Signature*	*Date*

[✓ Participant]/guardian:

Kiplyn Nelson	Kiplyn Nelson	4 / 13 / 16
Printed Name	*Signature*	*Date*

Photography Release Form

Date: 4-13-16

I am (Circle one): *Subject* [✓ *Parent*]*/Legal Guardian*

I, Kiplyn Nelson (Please Print) hereby grant permission to the students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

Traelyn Nelson	Traelyn Nelson	4/13/2016
Printed Name	*Signature*	*Date*

Participant/[✓ guardian]:

Kiplyn Nelson	Kiplyn Nelson	4/13/2016
Printed Name	*Signature*	*Date*

Photography Release Form

Date: 4/18/16

I am (Circle one): [✓ *Subject*] *Parent/Legal Guardian*

I, Kyle Nelson hereby grant permission to the
(Please Print)

students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

		/ /
Printed Name	*Signature*	*Date*

Participant/guardian:

Kyle Nelson		4/18/16
Printed Name	*Signature*	*Date*

Photography Release Form

Date: 4/21/16

I am (Circle one): [✓ *Subject*] *Parent/Legal Guardian*

I, Chandler Mitchell hereby grant permission to the
(Please Print)

students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

		/ /
Printed Name	*Signature*	*Date*

Participant/guardian:

Chandler Mitchell	Chan Mitchell	4/21/16
Printed Name	*Signature*	*Date*

Photography Release Form

Date: 4/19/16

I am (Circle one): [✓ *Subject*] *Parent/Legal Guardian*

I, Olufunsho Mary Oguntoyinbo hereby grant permission to the
(Please Print)

students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

		/ /
Printed Name	*Signature*	*Date*

Participant/guardian:

Olufunsho Mary Oguntoyinbo		04/09/2016
Printed Name	*Signature*	*Date*

Photography Release Form

Date: 4/19/16

I am (Circle one): [✓ *Subject*] *Parent/Legal Guardian*

I, Grant Mitchell hereby grant permission to the
(Please Print)

students Grant Mitchell and Kyle Nelson, and the advisor, Sclinda Janssen, to the use of all photographs of myself and/or my child for the purposes of their scholarly project. My signature indicates consent for use of photographs.

If applicable:

Child:

		/ /
Printed Name	*Signature*	*Date*

Participant/guardian:

Grant Mitchell		4/19/16
Printed Name	*Signature*	*Date*