The potential psychological benefits of Active Video Games in the rehabilitation of musculoskeletal injuries and deficiencies: A narrative review of the literature

Abstract

Background: Recent literature suggests that Active Video Games (AVGs) may offer potential psychological benefits during the rehabilitation of musculoskeletal injuries and their corresponding deficiencies. **Objectives:** To review existing literature regarding the potential psychological benefits of AVGs within the context of rehabilitation from musculoskeletal injury or debilitation. **Method:** A narrative review of the literature that used the *Population*, *Intervention*, *Comparison*, and *Outcomes* PICO method was conducted. The literature review included studies that discussed and/or investigated potential psychological benefits of AVGs during musculoskeletal rehabilitation. Of the total 163 papers that were identified, 30 met the inclusion criteria. **Results:** The *Nintendo*® *Wii*™ (Nintendo Co., Ltd, Kyoto, Japan) was the most commonly-used games console that was employed in AVG interventions (15 out of 21), and these studies that investigated potential psychological benefits were typically conducted with elderly populations. These studies reported that using AVGs in musculoskeletal rehabilitation resulted in a number of positive psychological effects (e.g., enjoyment, effects on self). However, most studies lacked a clear theoretical framework, and varied greatly in their designs and methodologies. **Conclusion:** Despite encouraging findings of AVG use, insufficient evidence exists to reliably verify or refute the potential psychological benefits of AVGs in musculoskeletal rehabilitation. It is recommended that future studies in this area contain a theoretical framework to ensure greater consistency in the methodology used and the execution of the intervention. The potential findings of such investigations may result in the development of optimal, client-tailored rehabilitation programmes.

Keywords: Exergaming; Interventions; Musculoskeletal; Psychosocial recovery

Introduction

Sport injury rehabilitation is typically considered to be successful when an athlete is both physically and psychologically ready to return to the athlete's sport.[1, 2] Research conducted with athletic trainers and athletic training students suggests that being psychologically ready for competition may be just as important as being physically ready.[1-3] However, when rehabilitating injured athletes, traditionally the focus of rehabilitation has been on the obvious physical symptoms, and the psychological components may have been overlooked.[4] A key aspect of successful rehabilitation from musculoskeletal injury or debilitation is to ensure that the patient is able to cope effectively with the rehabilitation process.[5] Rehabilitation professionals (RPs) who include physiotherapists and related practitioners, believe that there are three principal characteristics which determine the degree to which a patient will cope successfully with the process of rehabilitation: (1) attitude (i.e., positive/negative), (2) mood (i.e., stress, anxiety, anger, depression), and (3) rehabilitation behaviour i.e., adherence/compliance with rehabilitation; [6, 7-9] All three of the above characteristics are psychological constructs that influence overall physical and psychological recovery and rehabilitation outcomes.[10] These studies identify a number of strategies that RPs report using to facilitate a successful coping with the injury and subsequent rehabilitation process and return to activity following recovery. According to the RPs self-reported views, the three most commonly used strategies are: (1) creating variety in rehabilitation exercises, (2) setting short-term goals, and (3) encouraging positive self-thoughts.[6-9] Each strategy, if used appropriately and effectively, can facilitate beneficial change in the patient's attitude, mood, and/or rehabilitation behaviour.[10]

One way in which RPs could create variety in rehabilitation exercises is by incorporating Active Video Games (AVGs) as an adjunct to, or replacement for, more traditional rehabilitation modalities. Many traditional proprioceptive rehabilitation activities are unable to sustain injured patients' interest,[11] and in addition to the possible negative effects on injury recovery that may manifest themselves physically, a patient's loss of interest in performing rehabilitation activities may also have a negative effect on injured patients' attitude, mood, and rehabilitation behaviour.[6, 7] Indeed, playing with AVGs during rehabilitation has been proposed as having a positive impact on patients' balance and motion,[12] strength and flexibility,[13] enjoyment,[14] motivation,[15] and adherence,[16] as well as assisting clients who are experiencing too much pain or anxiety for them to relax.[13]

Despite the above claims, limited empirical research has been conducted to date that investigates the actual beneficial psychological impact of AVGs used during rehabilitation sessions. For example, Butler and Willet[17] discussed the potential for AVGs as a means of enhancing the psychological factors associated with successful rehabilitation from injury. However, their article only discussed the potential benefits, and did not include empirical intervention to test their claims, and did not contain a review of the relevant extant literature that currently exists. A concerted review of the literature regarding studies that employed AVG use is necessary in order to gain a better understanding of *how* AVGs may impact patients' psychological responses to the rehabilitation process, and obtain a comprehensive understanding of the theoretical frameworks used to underpin such interventions. Therefore, the purpose of this review is to conduct an evaluation of the existing literature which has examined the role of AVGs that are used in the rehabilitation of musculoskeletal injury or impairment, specifically focused on

the psychological responses to the rehabilitation process. The present review aims to answer the following research questions:

(1) What patient populations have reportedly used AVGs within the context of musculoskeletal rehabilitation?

(2) What AVG consoles have been used in the context of musculoskeletal rehabilitation?

(3) What psychological benefits have been found to exist when using AVGs as part of musculoskeletal rehabilitation programme?

(4) What psychological theoretical frameworks underpin the use of AVGs in the context of musculoskeletal rehabilitation?

(5) How can AVGs be used most effectively in the context of musculoskeletal rehabilitation?

Methods

Search strategy

The development of these research questions, and the subsequent search strategy that was employed was underpinned by the *Population*, *Intervention*, *Comparison*, and *Outcomes* (PICO) approach.[18] For the purposes of this study, each part of the PICO acronym is defined as follows:

Population: patients with musculoskeletal injuries or deficiencies undergoing some form of structured rehabilitation programme;

Intervention: Active Video Games (AVGs) are video games which require some form of physical activity or movement when played;

Comparison: different AVG consoles (e.g., *Nintendo® Wii™*, *Microsoft® Xbox 360®with Kinect™*;Microsoft Corporation, Redmond, WA, USA);

Outcome: the psychological benefits of AVGs as part of musculoskeletal rehabilitation.

The above definitions for PICO were used to inform the subsequent identification of relevant sources, the keyword combinations that were used in searches conducted, and the inclusion/exclusion criteria for the papers that were identified from these searches.

Sources and keywords

Two distinct sources of article retrieval were used for this study: First, electronic database searches were employed. These included: Academic Search, Bielefeld Academic Search Engine (BASE), CAB Abstracts, Cochrane Library, Cumulative Index to Nursing and Allied Health (CINAHL), CORE, FreeFullPDF, Google Scholar, IEEE Xplore, IngentaConnect, Mendeley, PsycINFO, PubMed, ScienceDirect, SPORTDiscus, and WorldWideScience. Second, the citations within the papers that had been retrieved from the electronic database searches were also scrutinized. When conducting the article retrieval, the Boolean operators, AND and OR were used when searching for keyword combinations. The keyword combinations included the following words and their variations: *virtual reality, audiovisual gaming, active video gaming, AVG, rehabilitation, Nintendo® Wii™, Wii™, Wii Fit™, XBox® Kinect™, PlayStation Move©, Wii-habilitation, sports injury, motion games, balance control, adherence, athletic training, physical therapy, physiotherapy, sports therapy, musculoskeletal, exergame(s),* and *functional.*

Inclusion criteria

Inclusion criteria were limited to research studies that specifically assessed psychological outcomes. Due to this being a novel area of research, no publication date limits were applied to the literature search. The literature review was limited to articles published in peer-reviewed journals, conference proceedings, abstracts, and unpublished theses that were written in English.

The review encompasses all published research studies that were conducted in sports, physical activity, and other non-neurological injury or illness rehabilitation domains. Particular focus included the role of AVGs in relation to the five research questions as stated in the aims that were explicated previously, specifically the identification of *psychological benefits* within the context of musculoskeletal rehabilitation. In addition, given the scarcity of research in this domain, and the overlap between certain injury rehabilitation and injury prevention programmes (e.g., fall prevention programmes and the rehabilitation of musculoskeletal injuries resulting from a fall), publications which examined or discussed the psychological benefits of AVGs when applied to programmes that were designed to increase musculoskeletal fitness/form/functioning were also included in this review.

Procedure

The search yielded a total of 163 publications. Both electronic and hard copies of the extracted publications were obtained for the creation of a master table that includes all 163 publications. This master table consists of the following information: publication authors, year of publication, publication type (e.g., media, conference proceedings, journal article, thesis), availability of full text publication, type of rehabilitation (e.g., in-patient, out-patient, home rehabilitation, sport injury, brain/stroke injury, inactivity intervention), the AVG platforms used (e.g., *Nintendo® Wii™*, *Microsoft® XBox 360® with Kinect™*, *PlayStationMove®* [Sony Computer Entertainment America LLC, San Mateo, CA, USA], or other), details of the participants (e.g., *N*, age, gender), outcome measures used (e.g., functional, psychological), and overall, those outcomes of the study reviewed (for details of the studies included in the final analyses, please see Table 2 in the Results section).

Based on the strict inclusion criterion that focuses on psychological benefits, 81 publications were eliminated since they did not measure or discuss psychological outcomes. In addition, since 52 publications used AVGs within the context of rehabilitation of a neurological injury/disorder (e.g., stroke), or an autoimmune disorder (e.g., systemic lupus erythematosus), they were excluded as they fell outside the scope of the present review. However, those studies that had a combination of participants classified as having a neurological injury, as well as participants who were deemed healthy, and/or had musculoskeletal injuries, were included in the analyses, but these results consist of only the non-neurological populations. The remaining publications were then assessed using a quality check list (see Table 1). Only those that met the quality criteria (n = 30) were included in the final analyses. Of those that met the quality criteria, 21 were empirical studies (one of which was an unpublished thesis), and nine were review/discussion articles.

INSERT TABLE 1 ABOUT HERE

Analysis

The content of the final 30 publications were assessed and analysed for information consistent with the research questions outlined above. First, details of each publication were documented into a master table. Each publication was then analysed separately for content for each of the five research questions presented in the introduction section. This data was then synthesized and arranged into meaningful units based on the themes that emerged.

Results

The purpose of this paper was to review existing literature which examined the potential psychological benefits of AVGs when used in the context of musculoskeletal rehabilitation.

Specifically, the review aimed to answer five research questions, each of which will be presented in the sections that follow. Table 2 displays details of the studies that were reviewed and are included in the final analyses.

INSERT TABLE 2 ABOUT HERE

Question 1: What patient populations have reportedly used AVGs within the context of musculoskeletal rehabilitation?

Of the studies included in the analyses, seven studies used AVGs as part of a balance training programme. Two studies[19,20] used AVGs as part of a fall prevention programme, while a total of five studies investigated the usefulness of AVGs as part of a musculoskeletal dysfunction programme (e.g., injury rehabilitation, teaching motor skills/motor disability, upper extremity dysfunction, impaired stepping). Only Manley, Arvinen-Barrow and Wallace[21] recruited injured athletes as participants for their study. In their multi-method intervention study, Manley et al. first conducted trials of AVG activities with previously injured athletes. After the trials, the athletes were interviewed about their perceptions and experiences of the usefulness of AVGs in relation to their sport injury rehabilitation. The results from the study indicated that despite elite athletes feeling more skeptical about the efficacy of AVGs within the context of sport injury rehabilitation, overall the athletes perceived AVGs as potentially effective adjunct to traditional injury rehabilitation programs in two ways: (1) enhancing positive emotional responses, and (2) increasing adherence to the rehabilitation process.

A total of ten articles explored the potential benefits of using AVGs as an intervention for exercise enhancement (with the aim of improving exercise attendance, fitness, muscular strength, balance, etc.). Eight of the 30 articles discussed the usefulness of AVGs in rehabilitation or as a

form of therapy, while one study[19] examined the motivation and gaming experience related to AVG use.

Typically, the populations used in the investigations varied from young adults to older adults (Age range = 16-94 years). A total of six studies used young adults or collegiate students, of which all but one [20] used healthy participants with no current injuries or impairments.[19, 21-24] Several studies (n = 8) used healthy adults as participants, who were usually recruited from health care centres. The majority of empirical studies, however, had been conducted with older adults (study sample ages ranged from 50 to 94) who were either (a) independent community dwelling older adults, or (b) those living in assisted living facilities and (long term) continuing care facilities.

Question 2: What AVG consoles have been used in the context of musculoskeletal (sport) injury rehabilitation?

Of the 21 empirical studies included in the analyses, 15 studies[19, 21-34] used *Nintendo Wii®* platforms (*Nintendo® Wii™* n = 8, and *Nintendo® Wii™* with Balance Board n = 7). Other studies employed custom-designed rehabilitation activities for wheelchair users using *Microsoft®, XBox 360®, Kinect ™*[20] custom-built movement mapping and guidance using *Microsoft®, XBox 360®, Kinect ™*,[35] Wobble board with a MTx motion tracker© (Xsens Technologies B.V., Enschede, The Netherlands),[36] a custom-designed closed Kinetic chain exercise game called WaterBall,[37] a Fitlinxx© (FitLinxx, Shelton, CT, USA) system for exercise tracking and feedback,[38] and a Tectrix© Virtual Reality Bike (Cybex International, Inc., Medway, MA, USA).[39] Although all of the review/discussion articles (n = 9) discussed the potential usefulness of the range of AVG platforms such as *Nintendo Wii®, Konami Dance Dance*

Revolution© (Konami Digital Entertainment, Inc., El Segundo, CA, USA) , *Microsoft XBox 360*® *Kinec* ™ *t* Sensor, the main emphasis of the articles was in the usefulness of *Nintendo*® *Wii* ™.

Commercial games that were used in the studies include: the *Wii*® *Sports* package software (e.g., tennis, baseball, bowling, golf and boxing), the *Wii*® *Sports Resort* package software (e.g., swordplay, Frisbee, archery, table tennis, golf, bowling, cycling), the *Wii Fit* ™ or *Wii Fit* ™ *Plus* package software including yoga, strength training, and aerobic games (e.g., hula hoop, basic step, basic run), and balance games (e.g., soccer heading, ski slalom, ski jump, table tilt, tightrope walk, balance bubble, penguin slide), the *Cooking Mama*© package software (Cooking Mama Ltd., Office Create, Japan), and the *Konami Dance Dance Revolution*© package software.

Question 3: What psychological benefits have been found to exist when using AVGs as part of musculoskeletal rehabilitation programmes?

The results from the literature review indicated several potential psychological benefits, as well as impairments. These will be presented in three separate subsections: cognitive, emotional and behavioural benefits (impairments will be supplemented where relevant).

Cognitive benefits

Engaging in AVG activities appeared to have a number of perceived cognitive benefits for individuals' cognitive appraisal of the factors associated with the AVG activity itself (i.e., perceptions about AVG usefulness for musculoskeletal rehabilitation, and enjoyment). In addition, participants' cognitive appraisals of themselves (i.e., intrinsic motivation, perceived positive effects on self) and their injury/impairment (i.e., perception of pain) were commonly reported to the researchers following bouts of AVG activity.

Perceptions about AVG usefulness for musculoskeletal rehabilitation. Seven studies reported participants' perceptions of the usefulness of AVG activities for musculoskeletal rehabilitation, but when obtained, such data was collected via patient self-evaluation reports, focus groups, and interviews. Positive perceptions of AVG usefulness were reported in five studies.[24, 25, 32, 40-42] Middlemas et al.[11] proposed that AVGs may be beneficial for sport injury rehabilitation because they offer both clients and practitioners new ways of thinking about athletic injury. Thus far only one empirical investigation exists which was conducted with athletes.[24] The authors of the aforementioned study learned that some of the previously injured participants felt that it would have been a good addition to use AVGs within their sport injury rehabilitation. However, the participants (especially those athletes who performed at a high level in their respective sport) believed that the activities may not have been beneficial simply because the AVG activities were not strenuous and/or challenging enough.

Enjoyment. A total of 18 papers indicated that engaging in AVG activities was generally viewed as enjoyable by the participants.[22-25, 27, 28, 30-32, 34-37, 40, 41, 43-45] Only one study[26] found no significant differences in participants' perceived enjoyment of AVG activities in comparison to traditional balance activities. In addition, although Hsu et al.[30] reported that there was increased participant enjoyment, they indicated that it is likely that the observed increases in enjoyment were not directly due to the AVG intervention itself, but rather the result of an order effect not accounted for within the research design (i.e., no counterbalancing of the order of AVG sessions was employed, with AVG sessions always taking place along with a standard regimen of more traditional exercise). The authors suggested that the observed increases in enjoyment could have been due to an overall feeling of enjoyment in response to either kind of physical activity,

whether it was owing to the AVG-based activity, or the more traditional form of physical activity.. Alternatively, the reported enjoyment by the participant may have been an artifact of participants' anticipation of the repeat sessions of AVG-based exercise that was scheduled for the future. It is possible that the scale used by the researchers was capturing something other than activity enjoyment. Furthermore, among the studies reviewed, there is great variation in the data collection methods for measuring enjoyment. Data were collected through standardized e.g., Physical Activity Enjoyment Scale, PACES;[46] and non-standardized (e.g., simple Likert-style questions such as "how enjoyable was your programme?") questionnaire designs, qualitative semi-structured/structured interview designs, focus groups, case reports, and participant observations.

(Intrinsic) motivation. Closely linked with participant enjoyment, several studies also measured possible increases in participant motivation that may be due to using AVGs. Di Tore[40] argued that AVGs have the potential to increase motivation simply because they are fascinating to the patient, but provided no theoretical or empirical support for their claim. Other studies suggested that AVGs have the potential to increase individuals' motivation to attend rehabilitation programmes and participate in related exercises[44] or therapy.[32] Wiemeyer[45] asserted that AVGs have been found to positively influence motivation.

However, based on our review, it appears that the results on the usefulness of AVGs as a motivational tool during musculoskeletal rehabilitation are inconclusive. These studies that follow support the contention that AVGs positively influence motivation: Da Gama et al.[35] found that their participants were highly motivated to complete the AVG exercises. Moreover, Chang et al.[20] found that motivation in relation to physical rehabilitation increased when AVGs

were used as a feedback tool, whilst Manley et al.[24] indicated that AVGs could be useful in motivating injured athletes to adhere to rehabilitation programmes by facilitating the setting of goals and targets. Increases in motivation to exercise following AVG interventions were also reported in three other studies.[21, 34, 43]However, while the review found that AVGs seem to positively influence motivation (like those studies above), often they were found to have no effect, and in some cases had deleterious effects, on patient motivation. Such studies revealed no significant differences in motivation between participants who engaged in AVG interventions and the control groups.[36, 39] Although reporting increases in motivation amongst participants who completed the *Wii* ™ intervention alone, Jacobs et al.[21] reported decreases in intrinsic motivation to engage in exercise amongst participants who participated in the *Wii* intervention with a partner, particularly over a period of time. Similarly, both Fung et al.[32] and Manley et al.[24] found that using AVGs had decrease participants' motivation toward traditional treatment methods, and as such, may not be beneficial as an adjunct method to traditional rehabilitation methods. Despite measuring motivation through both the Sports Motivation Scale[47] and Leisure Motivation Scale[48], Pasch et al.[19] did not report any clear results from these measures. Based on the interviews conducted, Pasch et al. concluded that for people who engage in AVGs as a recreational activity, a participant's motivation to participate in AVGs usually takes one of two forms: the motivation to achieve (i.e., improve score), or the motivation to relax. Of all the papers reviewed, only the study by Pasch et al.[19] investigated the possible relationship between personality traits and a participant's motivation to engage in AVGs. Still, Pasch and colleagues found no significant relationship between the variables assessed by the Big Five Personality

Inventory (i.e., Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism) and a patient's motivation to use AVGs.

As with enjoyment, the measurement of motivation also varied between studies. On the whole, the articles included in the present literature review utilized different self-report questionnaires measuring motivation, as well as structured interviews, and focus groups. In addition, Chang et al. used the number of correctly executed movements as a measure of motivation for completing the required rehabilitation exercises.

Perceived positive effects on self. Another finding which emerged from this literature review was that engaging in AVG activities may facilitate increases in participants' self-confidence and self-efficacy. Overall, a total of seven studies [25-27, 29, 34, 41, 45] discussed the positive impact of AVG activities on individuals' self-confidence and/or self-efficacy (both terms were often used interchangeably). For example, Coyne[41] presented case reports from private practice rehabilitation settings, and discovered that patients' self- confidence was affected in a positive way by the use of AVGs. Additionally, other studies were found to have a positive effect on patients' self-efficacy;[25, 45] and with paediatric patients, self-esteem AVG interventions also impacted older adults' self-confidence in dealing with technology in general, and in turn resulted in a decreased sense of feeling disconnected from the modern world.[34] Similar to enjoyment and motivation, the measurement of participants' confidence/efficacy also varied, with the terms "confidence" and "efficacy" often used interchangeably. Those articles that reported self-confidence and/or self-efficacy results used focus groups, participant comments, and anecdotal case reports as evidential support.

Some of the studies which involved AVGs as a balance training intervention also measured patients' balance confidence pre- and post-intervention. Interestingly, the results reported by most of these studies were rather counter-intuitive. Of the four studies directly reporting balance confidence/efficacy results, only Bainbridge et al.[29] found increases in participants' balance confidence, although even these results did not reach statistical significance. Bell et al.,[27] and Kliem and Wiemeyer[26] encountered no significant differences in balance confidence between AVG users and control groups, or pre- and post-intervention. Sauter[25] saw that the balance confidence of AVG group participants decreased post intervention. However, Sauter also observed that to start with, the AVG groups' balance confidence was noticeably, but not significantly, higher than the control group and other experimental groups, even after the intervention. Moreover, Brandt and Paniagua[43] found that among older adults in long-term care facilities, engagement in AVG activities was affected by balance confidence, since the participants did not like to use AVGs due to their fear of falling out of their chairs.

The studies that used AVGs for balance activities used different methods to measure confidence. Three of the balance confidence studies[25, 29, 31] used the Activities Balance Confidence Scale.[49] One study[27] applied the Modified Falls Efficacy Scale.[50], Another study utilized a structured interview.[43] Kliem and Wiemer[26] reported results from a Likert Scale question, asking: 'How confident are you to accomplish one leg stand without falling over for 30/45/60/75/90 seconds?'

Perception of, and working through pain. Of all the studies reviewed, only one study assessed participants' perceptions of pain. [30] Hsu et al. used the Numeric Rating Scale (NRS), which is a clinical measure aimed to quantify pain intensity, to assess older adults in long term

care facilities. They found no significant decreases in pain intensity levels post-AVG intervention, although they did find a non-significant reduction of pain bothersomeness (i.e., how much the pain causes disruption and aggravation to the patient). In addition, case reports from private practice settings have suggested that using AVGs as a treatment modality has helped patients work through pain with greater ease.[41]

Other cognitive benefits. Wiemeyer[45] suggested that AVGs have the potential to positively impact an individual's perception of control over their situation. However, the present review found that this was not empirically tested by Wiemeyer, or any other of the other studies. The use of AVGs has also been shown to have a beneficial impact on participants' overall mental stimulation amongst older women attending community health services, since the activities are proposed to stimulate new behaviours and learning in the form of using technology and gaming.[34]

Emotional Benefits

Another emergent psychological construct that has been investigated in the literature review is the effect of AVGs on individuals' mood and emotional response. The results reported are equivocal, based on both empirical and anecdotal evidence, and as with the cognitive constructs reported above, lack consistent methods of data collection.

Articles which reported positive changes in mood include Brandt,[43] who found engagement in AVGs were perceived as "exciting" by participants. Tsai[37] noted that based on researchers' observations participants became more talkative during the AVG sessions, in comparison to the non-AVG sessions. Furthermore, according to anecdotal case reports from private practice settings, practitioners have felt that participants' informal comments and

behaviours at the conclusion of AVG sessions have indicated that they were looking forward to the next session.[41]

Other studies[26] found no significant differences in mood states from either pre- and post-intervention, or between the AVG group and traditional balance training groups. Of the studies reviewed, two investigated the differences in flow states (i.e., the holistic experience that people feel when they act with total involvement),[51] between AVG and traditional group participants, but no significant differences were determined in either study.[26, 33] In a similar way, Annesi and Mazas[39] found no significant changes in exercise-induced feelings that were reported by participants in the AVG intervention group. However, the authors did note that those who had experienced the AVG and recumbent bike experimental conditions felt more rejuvenated after the combined exercise session than those in the traditional upright exercise bike group. Anecdotal evidence additionally suggests that participation in AVG activities may also have a negative effect on individuals' mood, as case reports have suggested that AVGs may have resulted in increased levels of frustration.[41]

Behavioural Benefits

In relation to the behavioural benefits of AVGs, three main constructs emerged from the data: (1) activity adherence/compliance, (2) participant engagement, and (3) social relationships.

Activity adherence/compliance. One of the most commonly investigated and reported psychological benefits of AVGs were treatment adherence/compliance. A total of four of the discussion articles[11, 41, 44, 52] proposed that AVGs were an effective means of increasing treatment adherence and/or compliance. Only Middlemas et al.[11] offered proposals specifically for sport injury contexts, however these claims were not supported by empirical evidence testing the

usefulness of AVGs for that purpose. Additional support via anecdotal case evidence from both private practice and paediatric hospital settings[41] demonstrated that use of AVGs can be beneficial in increasing adherence and compliance. In addition, visual feedback from a study testing the usefulness of *Microsoft XBox 360® Kinect™* -based rehabilitation support systems on motor rehabilitation guidance and movement correction[35] also indicated that use of AVG platforms can have a positive effect on treatment adherence. Empirical evidence seems to suggest that AVGs provide a means of increasing adherence to injury rehabilitation programmes/exercises. However, there was one exception: the empirical study of Sauter[25] found no significant differences in adherence between AVG and other experimental groups. Excluding this study, all other papers which measured this particular variable concluded that AVGs had a positive effect on adherence and/or compliance with injury rehabilitation activities.[27, 32, 38, 39]

Participant engagement. Only three of the studies reviewed explicitly discussed the benefits of AVGs on participant engagement (i.e., being actively involved in the activity). Tsai et al.[37] conducted post-intervention interviews and found that not only were participants heavily engaged in the AVG activities, they also expected to challenge other players during the gaming session, thus suggesting that AVG activities have the potential to elicit a sense of competition in participants. By using one of the five-point Likert scale questions, "How engaged were you during your programme?" Brumels et al.[22] revealed that AVG activities were perceived as more engaging than traditional balance programme exercises. In contrast, using the same question (but with a six-point Likert Scale), Kliem and Wiemeyer[26] found no significant difference in engagement levels between AVG and traditional balance exercise groups.

Social relationships. Another benefit of AVGs that has been observed in the literature is improved social relationships. The majority of papers investigating or discussing the use of AVGs with elderly populations indicated that engaging in AVG activities was enjoyable as it increased social interaction[27, 34, 37, 41, 43] and bridged the gap between generations.[28, 34, 37] Similar inferences have also been made for other age groups. For example, Brox et al.[44], Di Tore[40] and Wiemeyer[45] have all suggested that AVGs can be very social activities, and as such, have the potential to increase positive social interaction amongst people of all ages. Support for the above was found by Fung et al.[32] In their study with occupational and physical therapists working in hospital settings, participants felt that AVGs had the potential to increase social aspects of therapy. Brox et al.[44] did however, state that those involved in using AVGs need to be confident and familiar with the technology first in order to maximize social benefits.

Data for the above was typically collected via numerous self-report questionnaires, participant observations, structured and unstructured post-intervention interviews, focus groups and anecdotal case reports. Only one study[27] used a previously utilized and validated measure i.e., Social Provision Scale, SPA.[53] The results of this study using SPA measurements showed no significant differences in the social provisions between AVGs and other more traditional fall prevention programme groups.

Question 4: What psychological theoretical frameworks underpin the use of AVGs in the context of musculoskeletal rehabilitation?

Of the 30 articles included in the analyses, only one empirical research study explicitly described the theoretical models that underpinned their planned intervention.[19] Pasch et al.'s[19] research aims were two-fold: first, to investigate the motivation and gaming experience of four

393 experienced gamers via interviews; and second, to observe and record the movement of ten
394 graduate student gamers as they were playing the *Wii® Boxing* game. Pasch et al.[19] provided
395 brief details of theories they developed that explained individuals' motivation and applied them
396 to engagement in AVGs. The authors also discussed a number of theories of immersion that
397 served as potential theoretical frameworks (i.e., concept of flow and theories of immersion) to
398 explain the gaming experience. However, in the absence of clear theoretical frameworks
399 explaining motivation and gaming experience, Pasch et al.[19] adopted a Grounded Theory
400 approach to their data collection and analysis, and concluded that people who play AVGs, do so
401 for different motivational purposes with differing experiences (i.e., by 'playing the game' to
402 achieve or by 'simulating the game' to relax).
403 Three of the review/discussion articles[40, 44, 45] considered the importance of theoretical
404 frameworks for AVG design and development, as well as applied interventions. Brox et al.[44]
405 argued that AVGs can be used as a means to motivate and persuade older adults to exercise
406 simply due to them being fun and enjoyable; however, the authors failed to explicitly state which
407 psychological theory could be used to explain such reactions. Di Tore[40] proposed that when
408 developing AVGs for the purpose of teaching motor skills, the design and development process
409 should be guided by psychological models of movement (such as the cognitive and ecological
410 approach to movement). Wiemeyer[45] argued that any integration of AVGs into prevention,
411 rehabilitation, and education should be founded on detailed models of effect, rather than based
412 on the simple premise that AVGs act as a means of enhancing fun.
413 ***Question 5: How can AVGs be used most effectively in the context of musculoskeletal***
414 ***rehabilitation?***

Based on the results from the review, several applied and research recommendations for the role of AVGs in musculoskeletal rehabilitation were offered for consideration: social and contextual factors, sociodemographic factors, psychological factors, intervention characteristics, and intervention practicalities. Each recommendation is discussed in more detail below

Social and contextual factors

A number of social and contextual factors need to be considered when developing and implementing AVG interventions[33, 38]. Specifically, factors such as facility conditions and accessibility to AVG consoles were identified as important in predicting individuals' intentions of using such technology[33], but in what way, that was not clarified by the authors. Annesi[38] also recommended that if the aim of AVG intervention is to increase adherence by implementing computerized goal setting and feedback systems to replace professional human interaction, inclusion of range of social and contextual factors should be taken into account in the planning process.

Sociodemographic factors

In a similar manner, a range of sociodemographic factors may influence the usefulness of AVG interventions for musculoskeletal rehabilitation and therapy.[38] For example, gender differences[25] and personal preferences[34] regarding choice of games, as well as individuals' performance expectancies [33], may influence AVG intervention implementation and outcomes. Thus, the use of AVGs, just like any aspect of the rehabilitation programme/environment, should be specifically tailored to the needs of the client.

Psychological factors

Of the psychological factors relevant for AVG intervention development and implementation, it is likely that individuals' motivation to engage in AVG activities will be of importance.[19] It is also likely that clients' self-efficacy and confidence in terms of their perceived ability to use AVG technology and complete the required activities successfully will determine clients' thoughts, feelings and behaviours in response to such interventions. Thus, it is important to ensure that the target population is familiar with the AVG activities and feels confident about using them.[11, 41, 44] Such considerations will help to optimise the benefits of the planned intervention while reducing the risk of incurring harm.

Intervention characteristics

According to the literature, any AVG intervention should be underpinned by relevant theory (e.g., psychological and mechanical theories of movement).[40] As AVGs have the potential to aid in the correction of movement,[35] they need to be designed in such a way that allows for realistic transformation of clients' actions to sensory signals.[45] It has been suggested that commercial AVG platforms can be used in health care settings for health benefits and social wellbeing.[34] However, care should be taken when implementing such games with certain populations. For example, the use of AVGs for individuals with hemiparesis or hand problems could be detrimental to the client's functionality, furthermore, care should be taken when using AVGs with those who have experienced seizures,[41] since TV screens have the potential to trigger further episodes. AVG-based interventions should be motivating and variable,[26] ensuring that they are fun and entertaining as well as functional.[20] It is also suggested that by incorporating multiple users to engage in AVG rehabilitation activities simultaneously, such activities can be made more enjoyable and socially rewarding.[20] However, it is important that practitioners are

wary of the impact that competitive game-play can have on a client's progression and ultimate rehabilitation.[37]

Intervention practicalities

According to Wiemeyer,[45] the appropriate application of AVGs requires the establishment of a perfect fit of didactics, learning theory, and the respective AVG system. As with any treatment modality, the primary concern for the effective implementation of an AVG intervention is to ensure that related activities are specifically targeted and focused on the client's rehabilitation needs.[41, 54]

The planned AVG interventions should follow a structured gaming protocol, and additional time for a warm-up and cool-down should be incorporated into every session.[25] Consideration must also be given to the appropriate frequency and duration of the intervention,[29, 30] paying particular attention to the sociodemographic factors outlined above. Thus far, only two studies have made specific recommendations about the frequency and length of AVG interventions, suggesting that the appropriate frequency for AVG activities is twice weekly,[25, 32] with a 15-30 minute duration for each session.[32] Again, as with any traditional treatment modality, AVG interventions should be preceded with appropriate training, both for the clinician/practitioner[11, 41] and the client.[41] For example, Agmon et al.[28] indicated that to ensure the safe, effective and independent use of the *Nintendo® Wii ™* gaming system by older adults, more than five supervised training sessions would be required.

Middlemas et al.[11] also maintained that when planning on using commercial AVG platforms during sport injury rehabilitation, clinicians should note that these platforms were originally intended solely for entertainment. Thus, establishing an appropriate balance between gaming and learning is essential when utilising such commercially available AVGs.[45] In fact, it has

been recommended that such games be used as an adjunct to, rather than a replacement of, traditional therapy and/or exercise prescription.[11, 32, 44]

Discussion

The purpose of this paper was to review existing literature which has examined the potential psychological benefits of using AVGs within the context of rehabilitation from musculoskeletal injury, illness, deficiency, or impairment. Whilst a number of interesting and encouraging findings have been reported in relation to the above study aim, attempts to draw concrete conclusions and recommendations from the analyses is hampered somewhat by the lack of consistency among studies in terms of the participant samples recruited, the experimental designs employed, and the methods of data collection/analysis conducted. For example, given the differences in physical fitness between traditional sport injury rehabilitation participants and the more typical populations studied to date (i.e., older adults), it is likely that the results are not directly comparable, thus reflecting a need to account for important differences between prospective patient populations. What was surprising from the findings of the reviewed papers was the notion that AVG interventions had primarily employed the *Nintendo® Wii™*. Not one study **in which psychological outcomes were measured in a musculoskeletal injury context utilized** the commercially available *Microsoft XBox 360®* with *Kinect™*Sensor. The use of *Nintendo® Wii™* has been shown to have various benefits in rehabilitation contexts, particularly with older adult populations. However, with injured athletes, the movement mechanics detected and reflected using equipment such as *Microsoft®'s Kinect™* Sensor might serve a better and more functional purpose for practitioners interested in using AVGs to engage, monitor, and assess these patients. With the aim to design AVG interventions that allow realistic

transformation of patients' actions to sensory signals,[45] it is likely that the technical specifications of *Kinect™* may be more suited to musculoskeletal sport injury rehabilitation both functionally (i.e., allows more realistic movement with different treatment aids) and psychosocially (i.e., allows the creation of more challenging, motivating and engaging rehabilitation environments). However, further research is clearly warranted in order to verify or refute this particular contention. When conducting the review of literature, gaming, and human computer literature was also included in the searches. However, many of these studies were excluded since did not meet the inclusion criteria and were outside of the scope of this review. Only studies that investigated psychological outcomes as measured in musculoskeletal injury contexts were included.

From a psychological perspective, which is the main scope of this review, the results reveal that AVG interventions have the potential to positively affect individuals' cognitive appraisals of themselves and their rehabilitation situations, and might also provide a number of emotional and behavioural benefits during musculoskeletal rehabilitation. Consistent with the Integrated Model of Psychological Response to the Sport Injury and Rehabilitation Process,[10] as well as the research findings outlined earlier in the Introduction section,[6-9] these psychological constructs (i.e., cognitive appraisals, emotional, and behavioural responses) can in turn influence not only the actual rehabilitation process, but also the physical and psychosocial rehabilitation outcomes. How these constructs manifest, interact and affect the rehabilitation process as a result of AVG intervention also warrants further investigation.

It appears that many of the studies conducted to date lack specific theoretical frameworks. This can be problematic for a number of reasons: (a) the studies do not provide

524 researchers with a clear description of methodologies used, which (b) limits replicability and
525 fails to provide opportunities for systematic collection of data, while (c) some of the
526 psychological constructs measured and reported by patients may not be those initially intended
527 for assessment. By drawing on the preliminary results from this review, as well as the general
528 literature related to the psychology of injury rehabilitation, it is proposed that the
529 Biopsychosocial Model of Sport Injury Rehabilitation[55] (Figure 1) could help provide
530 researchers and applied practitioners/clinicians with a useful theoretical framework as the basis
531 for future research and the development of applied AVG interventions. The Biopsychosocial
532 Model[55] "draws upon approaches increasingly adopted in the healthcare professions which
533 suggest that health, illness, and injury are best understood in terms of an interaction between
534 biological, psychological and social factors, rather than in purely biological terms as is
535 traditional in medicine."[56] At the core of the model are biological (e.g., metabolism, tissue repair,
536 sleep), psychological (e.g., personality, cognition, affect and behaviour) and social/contextual
537 factors (e.g., social networks, life stress, rehabilitation environment), all of which are seen as
538 having the potential to influence one another. These three factors are also mediated by the
539 characteristics of injury (e.g., type, cause, severity, and location) and a number of
540 sociodemographic (e.g., age, gender, socioeconomic status) factors. The model assumes that
541 biological, psychological, and social/contextual factors also have an effect on the intermediate
542 biopsychological rehabilitation and recovery outcomes (e.g., range of motion, strength, pain, rate
543 of recovery). Along with psychological factors, the intermediate biopsychological outcomes also
544 have a bi-directional relationship with overall injury rehabilitation outcomes (e.g., functional

545 performance, quality of life, treatment satisfaction and readiness to return to optimal
546 functioning).

547 By creating variability in rehabilitation exercises (i.e., using AVG interventions as a
548 treatment modality), researchers and applied practitioners are manipulating the rehabilitation
549 environment (i.e., social/contextual factor). Existing evidence from the current review (albeit
550 partially limited and conflicting due to inconsistent methodology and design) suggests that AVG
551 interventions can have a positive impact on patients' cognitions, affective responses and
552 behaviours (i.e., psychological factors). Evidence has also suggested that various intermediate
553 biopsychological and injury rehabilitation outcomes can be affected by AVG interventions;
554 although, thus far it appears that differences in functional outcome measures between AVG and
555 traditional balance rehabilitation activities have not been reported.[26, 27, 30, 31] The current results
556 also indicate that a range of sociodemographic factors (e.g., age, physical health) may influence
557 successful AVG intervention implementation. Furthermore, it is likely that injury characteristics
558 and biological factors (e.g., individuals with hemiparesis or hand problems) will play a role in
559 the planning, design and overall usefulness of AVG interventions in injury rehabilitation
560 contexts.[41] By using the Biopsychosocial Model as a framework, both researchers and applied
561 practitioners/clinicians can provide a clear structure and robust foundation for their interventions.
562 Through the Biopsychosocial Model, a number of factors could be tested and/or controlled for
563 simultaneously, thus providing an integrated approach to the interventions. This could then be
564 coupled with a framework that forms the basis for different phases of rehabilitation,[57] as well as
565 relevant theories underpinning the chosen constructs to be measured e.g., adherence;[58,] or mood;

[59, 60] thus making any proposed interventions not only structured and easy to replicate and monitor, but also purposeful and grounded in appropriate theory and evidence.

Conclusions

By conducting a review of the relevant extant literature, the purpose of this paper was to examine the extent to which AVGs provide psychological benefits for patients undergoing rehabilitation from musculoskeletal injury, deficiency, or impairment. The research to date appears to lack clear theoretical frameworks, and consistent methodologies; as such, the results are inconsistent and contradictory. However, the initial evidence is encouraging. These studies indicate that AVG interventions have been effective in facilitating short-term psychological (and in turn, physical) benefits to clients participating in a variety of rehabilitation programmes. Despite this, the long-term effects are still unknown,[45] and the effectiveness of AVG interventions requires additional investigation utilizing appropriate research designs, measurement items, and outcome variables.[41] In conclusion, it is suggested that the Biopsychosocial Model of Sport Injury Rehabilitation[55] could be a useful framework for future research and applied intervention designs.

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