Adults with Parkinson’s Disease Undergoes Exergaming Training to Improve Balance: A Systematic Review

Yu-Tai Wu, Yu-Feng Wu, and Jian-Hong Ye

Abstract—Parkinson’s disease (PD) is a neurodegenerative disease, which is affecting millions of people globally. One common problem in PD patients are postural instability which can lead to balance control impairment. PD patients’ postural instability is currently one of the most difficult challenges the physician encounters when treating the patients with this long duration of disease. However, previous studies have shown that exergaming is a popular treatment for improving balance of PD patients. The purpose of this study was systematic review of exergaming training intervention and outcomes of balance among participants with PD. The search terms “exergaming,” “exergames,” “balance,” “Parkinson’s disease” “Virtual reality” and “Postural instability” were used in three electronic databases, Science direct, Pubmed and Scopus. eleven studies were systematically reviewed using the synthesis matrix. The results indicated that the exergaming training group of PD participants ranged from 1 to 76. The training duration and frequency was between 20 minutes to 60 minutes, one to three times a week, for a period of 6 to 12 weeks. In terms of research methodology, most studies reviewed conducted randomized controlled trial, while two studies administered semi-experimental design and one study conducted single subject experimental design. The results of these studies indicated many benefits of exergaming training among PD participants, such as, balance, gait, fatigue and postural instability. In conclusion exergaming intervention is recommended as postural stability treatment for PD participants. This study may be used as a guide for future reference when designing exergaming balance training for future studies or rehabilitation application.

Index Terms—Postural stability, embodied learning theory, virtual reality, Wii, Xbox.

I. INTRODUCTION

Parkinson’s disease (PD) is a worldwide illness, with an occurrence rate of 4.5 to 19 people per 100,000 populations per year [1] (World Health Organization, 2006). PD is a neurodegenerative disease, which is affecting seven million people globally [2] (Zafari, Amiri, & Taherian, 2017) and known to effect individuals’ postural instability [3] (Lee, Altmann, McFarland, & Hass, 2016). The instability of the postural may be present in the early stage of the disease and become worse as the PD progresses [4] (Jankovic, 2008). It is found that the frequency of individuals with Parkinson’s disease (PD) fall twice as much as neurotypical people [5] (Allen, Schwarzel, & Canning 2013). Postural instability among individuals with PD not only lead to balance control impairment, an increase in fear of falling and losing balance confidence [6] (Adkin, Frank, & Jog, 2003).

According to [1] World Health Organization (2006) PD patients face many difficulties, such as, freezing of gait, postural instability and falls, which are associated to patients’ balance. In addition, PD patients face many neuromechanical impairments, such as anticipatory postural adjustments (APAs) and automatic postural reactions (APRs) that affects the movement coordination and postural instability [7] (Carpenter, Allum, Honeygge, Adkin, & Bloem, 2004; [8] Massion, 1998). Furthermore, the joint stiffness is also a common problem postural responses. In fact, these play out to be a great influence to postural influence even when standing. Postural instability is currently one of the most difficult challenges the physician encounters when treating the patients with this long duration of disease [1] (World Health Organization, 2006).

However, exergaming is a popular intervention, as can be seen, in recent years’ technologies such as virtual reality and exergaming software, is increasing rapidly in neurological rehabilitation [9] (Mirelman, Maidan, & Deutsch, 2013). Games that involves in exercising while playing for health benefits, which requires the movement of the body in order to continue with the game and helps increases physical activity levels is known as “Exergames”. Convincingly, exergaming holds promises that it is more effective comparing to other programs that contain physical activity [10] (Gao, Chen, Pasco, & Pope, 2015). Therefore, exergaming may be an implement for avoiding or decelerating the pace of losses in postural control and functional balance.

According to the embodied learning theory, which comprises learning activities with the requirement of body engagement and provides people with improved knowledge retention and learning performance. People’s thought and reasoning have been argued that embodied cognition are deeply associated to the sensorimotor, at the same time as the interaction of physical environment is connected to the body [11] (Barsalou, 1999; [12] Glenberg, 2010). Moreover, embodied learning requires that the individuals have a meaningful connection, where learning is required to be associated with physical, embodied experience [13] (Merjamin, 2008).

In the world today, technology is advancing its growth in a fast pace, which allowed the capabilities of interface within digital technology to gradually enable people to have connection with computers easier than ever [14] (Jacob et al., 2008). In recent years, the technology advancement has become easier for individuals to interact, taking mobile phones and tablet computers for example, these technologies
have made it an easy movement with augmented camera views making the physical interface combining with virtual and physical settings, which is now known as “mixed reality” [15] (Milgram & Kishino, 1994). Numerous studies have defined the extension of repertoires of interaction, and have indicated that understanding and learning the theory of embodied learning is important [16] (Bujak et al., 2013; [17] Chang, Lee, Wang, & Chen, 2010; [18] Lindgren & Johnson-Glenberg, 2013). [19] Resnick (2006) specified that “conceptual leverage can be led by digital technologies so that learners to accomplish embodied activities.

Augmented viruality (AV) is known to improve people embodiments. The AV includes interfaces that requires interaction and devices that can bring elements to the real world, known as virtual reality environment, this environment is regarded as “mixed reality” [15] (Milgram & Kishino, 1994; [20] Simsarian & Akesson, 1997). This environment not only bring sense of presence, as well as giving individuals feedbacks and interactions [21] (Kim, Prestopnik, & Biocca, 2014). Exergaming is an example of augmented virtuality, since it has virtual environment where motion devices are performed. For example, pressure sensors or devices that is able to track the motions of the body. These devices allow people to experience the real world, and the exergames allows it to respond to the gestures and physical activity of the user [22] (Won, Bailenson, & Janssen, 2014).

The research designs, exergaming intervention designs and outcomes of previous studies all differ significantly. Thus the purpose of this study was systematic review of exergaming training intervention and outcomes of balance among participants with PD. In addition, this study aims to identify the benefits of exergaming training in improving balance among participants with PD. The results in this study may be used as a guide for future reference when designing exergaming balance training for future studies or rehabilitation application.

II. METHODS

To conduct this systematic review, a synthesis matrix was used. This type of method is widely used in literature review, especially in health sciences. In this study, the matrix consists of columns and row, where the column is composed of variables and topics, and the rows composed of literature. A critical analysis method such as synthesis matrix is often used to develop future research.

In this study, the search terms were used “exergaming,” “exergames,” “balance,” “Parkinson’s disease” “Virtual reality” and “Postural instability”. The search covered three electronic databases, Science direct, Pubmed and Scopus were searched, from 2013 to 2019, to identify relevant studies. In addition, this study only included studies in English and articles that were not theoretical, introductory or review articles. Participants without Parkinson disease and studies with traditional exercise for balance training were excluded from the search. There were four reviewers that conducted the systematic review. The first reviewer was a doctoral student from department of physical education and department of industrial education. To ensure the accuracy of the selection of studies, four reviewer did a cross comparison while discussing together.

Several criteria were used in the selection of the articles. First all studies that used qualitative analysis were excluded in the study. Second exergaming therapy for balance was the intervention of all the studies. Finally, 82 articles were identified in the searching process. However, studies that included other types of balance therapy and other types of disease were excluded in the study. After the elimination of duplicates and irrelevant studies 11 studies were analyzed. The following flow chart of the searching process can be seen in the Fig. 1 below.

III. RESULTS

In this study, 11 articles were used in the synthesis matrix. First, the experimental designs discussed in Table I were assessed to the type of intervention, such as participants, group types, approach and the Parkinson disease stages of the participants. Second, in Table II the results indicated the type of kits, the type of training and the duration and frequency of each experiment conducted in the 11 studies. Lastly, Table III shows outcome indicator and findings.

A. Participants

In the studies reviewed, each indicated the number of the participants that participated in their study. As can be seen, studies conducted by [23] Gandolfi et al., (2017) had the most participants accounting for 76 participants. However, there were some limitations in sample sizes in other studies [24] (Ribas et al., 2017; [25] Negrini et al., 2017; [26] Yang et al., 2016; [27] Shih et al., 2016; [28] Cracoviensia et al., 2013; [29] Mhatre, et al., 2013) all had below 30 participants except for the study conducted by [30] Henrique, Colussi, & De Marchi, (2019) and [31] Liao et al., (2015), which had participants a little more than 30 participants. It is notable that there was one study that only had one participant [32] (Vallabhajosula, McMillion & Freund, 2017). In addition, only 5 studies [24] (Ribas et al., 2017; [25] Negrini et al., 2017; [32] Vallabhajosula, McMillion and Freund, 2017; [28]}
Cracoviensia et al. 2013; [29] Mhatre, et al., 2013 indicated the
gender of the participants, also indicated the age of the
participants. However, it can be seen that more males were
chosen as the participants than females for all studies. While
three studies indicated the age of the participants without
indicating the gender of the participants [30] (Henrique,
Colussi, & De Marchi, 2019; [33] Harris et. al., 2018; [26]
Yang et al., 2016).

B. Experimental Design

8 exergaming studies have applied randomized control
trial (RCT) [30] (Henrique, Colussi, & De Marchi, 2019; [33]
Harris et al., 2018; [24] Ribas et al., 2017; [23] Gandolfi et
al., 2017; [26] Yang et al., 2016; [27] Shih et al., 2016; [28]
Cracoviensia et al. 2013; [29] Mhatre, et al., 2013). Randomized
control trial has been indicated as strong research design because of a strong reliability [34] (Begg et al., 1996). Other two studies have applied semi-experimental design [23] (Gandolfi et al., 2017; [28] Cracoviensia et al. 2013). While one study conducted Single subject experimental design, this indicated the study only focused primarily on one participant [32] (Vallabhajosula, McMillion & Freund, 2017).

Furthermore, pre-test and post-test of exergaming training outcome were used only by two studies [27] (Shih et al., 2016; [29] Mhatre, et al., 2013) while the rest of the study compared between two groups. For example, studies from [24] Ribas et al., (2017) compared between two groups exergaming group and control group. While studies from [25] Negrini et al., 2017 compared whether 10 or 15 rehabilitation sessions of Nintendo Wii Fit will have different outcome. In addition, only one study compared 3 groups virtual reality-based Wii fit exercise group, traditional exercise and control group. However, 3 studies did not have any comparisons [32] (Vallabhajosula, McMillion & Freund, 2017; [28] Cracoviensia et al. 2013; [29] Mhatre, et al., 2013)

C. Parkinson Disease Stage

All studies used Hoehn & Yahr scale to determine the stages of the Parkinson Disease among patients, except for two studies [30] (Henrique, Colussi, & De Marchi, 2019; [25] Negrini et al., 2017). As can be seen, some studies accepted participant’s with PD stage I through stage III [24] (Ribas et al., 2017; [27] Shih et al., 2016; [31] Liao et al., 2015). This suggested that the level of influence the PD patients faces will differ significantly. Thus, four studies chose participants who were more related in terms of the PD stages. Therefore, the result will be more consistent and rigorous [32] (Vallabhajosula, McMillion & Freund, 2017; [23] Gandolfi et al., 2017; [26] Yang et al., 2016; [29] Mhatre, et al., 2013).

| Author          | Participants | Group types | Approach          | PD Stage |
|-----------------|--------------|-------------|-------------------|----------|
| [33]            | older        | (b)exergaming + sham-a-iDCS | Randomized controlled trial | score 2–4 |
| Ribas et al. (2017) | Male: 12 | (a)exergaming group (n=10) | Randomized controlled trial | stage I, II or III based on the modified Hoehn & Yahr scale |
| [24]            | Age: 40-80   | (b)control group (n=10) |   |   |
| Negrini et al. (2017) | Male: 14 | (a)10 sessions | Semi-experimental design |   |
| [25]            | Age: 50-90   | (b)15 sessions |   |   |
| Vallabhajosula et al. (2017) | Male: 1 | A case study | Single subject experimental design | stage III on the Hoehn and Yahr scale |
| [32]            | Age: 69      |   |   |   |
| Gandolfi et al. (2017) | 76 participants | (a)VRterhabilitation (n = 38) | Randomized controlled trial |   |
| [23]            |   | (b)in-clinic SBT (n = 38) |   |   |
| Yang et al. (2016) | 23 participants | (a)home-based virtual reality | Randomized controlled trial | Hoehn/Yahr Stages II to III |
| [26]            | Age: 55-85   | (b)conventional home balance training (n=12) |   |   |
| Shih et al. (2016) | 20 participants | (a)Balanced based exergaming (10) | Randomized controlled trial | Hoehn and Yahr |
| [27]            |   | (b)Balance training (10) | stages I through III |   |
| Liao et al. (2015) | 36 participants | (a)virtual reality-based Wii fit exercise (VRWii group) (n=12) | Randomized controlled trial | Hoehn and Yahr Stages I to III |
| [31]            |   | (b)Traditional exercise (n=12) |   |   |
| (c)Control group (n=12) |   |   |   |   |
| Cracoviensia et al. (2013) | Male: 17 | N/A | Semi-experimetal design | Hoehn & Yahr scale |
| [28]            | Female: 7    |   |   |   |
| Mhatre et al. (2013) | Male: 4 | N/A | Randomized controlled trial | Hoehn and Yahr Stages 2.5 or 3 |
| [29]            | Female: 6    |   |   |   |

D. Kit and Training

There were two studies that used different exergaming kit [30] (Henrique, Colussi, & De Marchi, 2019; [33] Harris et al., 2018) which used Motion Rehab AVE 3D and Augmentative virtual reality software (Jintronix, Montreal, QC, Canada) with concurrent a-iDCS. The kit that were used in the two studies were not as home based kit like the other six studies, which used Wii Fit kit as the exergaming instruments [24] (Ribas et al., 2017; [25] Negrini et al., 2017 [23] Gandolfi et al., 2017; [31] Liao et al., 2015; [28] Cracoviensia et al. 2013; [29] Mhatre, et al., 2013), since Wii Fit has balance board is convenient to measure the balance of...
the participants. All training games played by the participants were all related to balance or postural stability. However, there were some limitations when using Wii Fit and Xbox Kinect kit, the sample size was not large for all the studies except for the study that used visual reality [23] (Gandolfi et al., 2017). Thus, this can be that visual reality exergaming were able to conduct a larger sample size compared to Wii Fit and Xbox Kinect.

It is notable that the training games used were fun and challenging in these studies, which can enhance participants interest while training their balance and postural stability. Moreover, embodied learning requires that the individuals have a meaningful connection, where learning is required to be associated with physical, embodied experience [13] (Merriam, 2008). As can be seen these games have all acquired embodied experiences and that it can be a stated as “conceptual leverage” as these digital technologies can accomplish embodied activities [19] (Resnick, 2006).

E. Duration and Frequency

The duration of the exergaming training was between 20 minutes to 60 minutes while in most studies 30 minute sessions were the most common duration of the exergaming balance training for the PD participants, while 50 minute sessions were the second most among the studies. Most of the studies frequency of the exergaming training intervention were twice a week over 6 weeks and 8-week period. The longest frequency was over a 12-week period intervention. (see Table II)

![Image](image_url)

| Author | Kit | Duration | Frequency | Training |
|--------|-----|----------|-----------|----------|
| Vallabhajosula et al. (2017) | treadmill walking and Xbox Kinect exergaming | 30 minutes | 8 weeks | 1. Walking speed 5 to 10% each week |
| | | | | 2. Boxing |
| | | | | 3. Bowling |
| | | | | 4. Table Tennis |
| Gandolfi et al. (2017) | Wii Fit | 50 minutes | 3 days/week for 7 consecutive weeks | 1. Rhythm parade |
| | | | | 2. Penguin Slide |
| | | | | 3. Ski slalom |
| | | | | 4. Snowball fight |
| | | | | 5. Bird’s-eye \(s\) 6. Perfeet 10 |
| | | | | 7. Table lift |
| | | | | 8. Balance bubble |
| | | | | 9. Tilt city |
| | | | | 10. Skateboarding |
| Yang et al. (2016) | VR balance training system | 50 minutes | Twice per week for 6 weeks | 1. Star excursion |
| | | | | 2. Apple catching |
| | | | | 3. Park walking |
| | | | | 4. Car racing |
| | | | | 5. Cloth Washing |
| | | | | 6. Cooking |
| | | | | 7. Home Yoga |
| | | | | 8. Table tilt |
| Shih et al. (2016) | Kinect sensor | 50 minutes | Twice per week for 8 weeks | 1. Reaching task (stationary object) |
| | | | | 2. Reaching task (moving object) |
| | | | | 3. Obstacle advance (avoid upcoming object) |
| | | | | 4. Marching (step alternatively) |
| Liao et al. (2015) | Wii Fit | 60 minutes | Twice a week over 6 weeks | 1. VR/Wii group Wii fit exercised and treadmill training |
| | | | | 2. TE group traditional exercise and treadmill training |
| | | | | 3. Control group |
| | | | | 4. Fall prevention education |
| Cracoviensia et al. (2013) | Wii Fit | 20 minutes | Twice a day every day for 6 weeks | 1. Ski Slalom |
| | | | | 2. Balance Bubble |
| | | | | 3. Control group |
| | | | | 4. Fall prevention education |
| Mhatre et al. (2013) | Wii Fit | 30 minutes | 3 times per week for 8 weeks | 1. Marble tracking |
| | | | | 2. Skiing |
| | | | | 3. Bubble rafting |

F. Outcome Indicator

All studies reviewed used scales and software’s to measure the PD participants balance or postural stability which can be seen in Table III. The common scales used to determine balance was with Berg balance scale. Moreover, scales and measurements related to balance and functional stability.
conducted in the reviewed studies were Berg scale, Falls risk test, Stability index, Tinetti scale, Falls Efficacy Scale–International, Mini-Balance Evaluation Systems Test, Dynamic Gait Index, timed Up-and-Go test, Limits of stability (LOS), One-leg stance (OLS), Tinnet’s Performance-Oriented Mobility Assessment, Activities-specific Balance Confidence scale. Thus, there will be different findings on exergaming intervention on balance among participants with Parkinson’s Disease.

G. Findings

Exergaming has shown significant balance improvement among PD participants Balance-based exergaming training gained a positive effect in the postural stability when comparing to conventional balance training [27] (Shih et al., 2016). According to [24] Ribas et al., (2017) study, it showed significant improvement in balance and fatigue after 12 weeks of exergaming in Wii Fit, while [32] Vallabhasjula, McMillion & Freund, (2017) suggested that there was positive improvement in gait among PD participants. Moreover, it is suggested that virtual reality Wii Fit exergaming showed that exergaming improved significantly for PD participants in obstacle crossing performance and dynamic balance [31] (Liao et al., 2015). Another study mentioned that virtual reality exergaming can be an alternative to in-clinic, as it can reduce postural instability in PD patients [23] (Gandolfi et al., 2017).

Furthermore, both studies [28] Cracoviensia et al. (2013); [29] Mhatre, et al., (2013) are also an evident that exergaming intervention improves balance. exergaming holds promises that it is more effective comparing to other programs that contain physical activity [10] (Gao, Chen, Pasco, & Pope, 2015). Thus exergaming could be a tool for preventing or slowing the pace of functional losses such as balance and postural control. The duration of sessions indicated by [25] Negrini et al., (2017) study provided evidence that 10 sessions of exercise and 15 sessions of exergaming in both groups improved the same way. Thus, this proves that the 10 sessions and 15 sessions of exergaming will have the same outcome in balance among PD participants.

| Author                | Outcome Indicator                                                                 | Findings                                                                                      |
|-----------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Henrique et al. (2019)| 1. Modified Ashworth Scale                                                       | 1. Both groups, patients obtained significant improvement.                                    |
|                       | 2. Fugl-Meyer Assessment                                                          | 2. Rehabilitation using exergaming in post-stroke patients could be a more efficient way and a reduction alternative for improving balance and upper limb motor function. |
|                       | 3. Berg Balance Scale                                                             |                                                                                               |
| Harris et al. (2018)  | 1. Limits of Stability Test                                                       | Improvements in functional, neurocognitive, balance and neurophysiological outcome measures will be greater and longer-lasting following concurrent exergaming and |
|                       | 2. static balance                                                                 |                                                                                               |
|                       | 3. leg strength,                                                                  |                                                                                               |
|                       | 4. functional capacity                                                            |                                                                                               |
|                       | 5. cognitive task related                                                          |                                                                                               |
|                       | cortical activation                                                              |                                                                                               |
| Cracoviensia et al. 2013 | 1. The Activities-specific Balance Confidence (ABC)                             | Virtual reality with Will showed significant improvement in PD patients’ balance and motor disability |
|                       | 2. Unified Parkinson’s Disease Rating                                              |                                                                                               |
|                       | 3. The sit-to-stand test (STST)                                                    |                                                                                               |
|                       | 4. The Timed Up-and-Go (TUG) 5. 10-Meter Walk Test (10MWT)                        |                                                                                               |
|                       | 6. Tinnet’s Performance-Oriented Mobility                                         |                                                                                               |
Barsalou, 1999; [12] Glenberg, 2010. Connected to the body, which is an evident that exergaming same time as the interaction of physical environment is cognition is deeply associated to the sensorimotor, at the Embodied learning theory involves engaging the body in Gandolfi, 2013. Among other studies, this could be that Wii fit provides balance board. The longest duration of training was 60 among participants with PD. The systematic review identified 11 studies comparing different exergaming kits and tools and alternative intervention in PD participants [30] (Henrique, Colussi, & De Marchi, 2019; [33] Harris et. al., 2018; [24] Ribas et al., 2017; [23] Gandolfi et al., 2017; [26] Yang et al., 2016; [27] Shih et al., 2016; [28] Cracoviensia et al. 2013; [29] Mhatre, et al., 2013; [34] Begg et al., 1996; [23] Gandolfi et al., 2017; [28] Cracoviensia et al. 2013). Embodied learning theory involves engaging the body in learning activities which can provide individuals with better learning performance and knowledge retention. Embodied cognition is deeply associated to the sensorimotor, at the same time as the interaction of physical environment is connected to the body, which is an evident that exergaming works as a rehabilitation tool for participants with PD [11] (Barsalou, 1999; [12] Glenberg, 2010.

Wii fit was found to be the more popular intervention among other studies, this could be that Wii fit provides balance board. The longest duration of training was 60 minutes [31] (Liao et al., 2015). More than half of the studies conducted a 30 min exergaming intervention [30]Henrique et al., 2019 [33] Harris et al., 2018; [24] Ribas et al., 2017; [25]Negrini et al., 2017; [32]Vallabhajosula et al., 2017; [29]Mhatre et al., 2013). However, another study results found that for as little as 20 minutes of exergaming can improve balance in PD patients [28] (Cracoviensia et al. 2013). Most of the studies frequency of the exergaming training intervention were twice a week over 6 weeks and 8-week period. The longest frequency was over a 12-week period intervention. [30] (Henrique, Colussi, & De Marchi, 2019; [33] Harris et. al., 2018; [24] Ribas et al., 2017; [23] Gandolfi et al., 2017; [26] Yang et al., 2016; [27] Shih et al., 2016; [28] Cracoviensia et al. 2013; [29] Mhatre et al., 2013; [34] Begg et al., 1996; [23] Gandolfi et al., 2017; [28] Cracoviensia et al. 2013). As can be seen these games have all acquired embodied experiences and that it can be a stated as “conceptual leverage” as these digital technologies can accomplish embodied activities [19] (Resnick, 2006).

Furthermore, the results also showed that 10 sessions and 15 session have the same effect on balance performance among PD patients [25] (Negrini et al., 2017). Exergaming training for balance positively improved the postural instability when comparing with conventional balance training [27] (Shih et al., 2016). In addition, another study found that exergaming also had positive effect improving balance and fatigue reduction in PD patients after 12 weeks of training. However, this benefit did not continue in the long-term. In conclusion, exergaming intervention is recommended as postural stability treatment for PD participants.

V. CONCLUSION

PD is a neurodegenerative disease, which affects millions of people globally [2] (Zafari, Amiri, & Taherian, 2017). Which in result PD participants encounter postural instability in the early stage of the disease and become worse as the PD progresses [4] (Jankovic, 2008). As the PD progresses patients fall as much as neurotypical people [5] (Allen, Schwarzel, & Canning2013). This becomes a problem, since postural instability are found to be a difficult challenge for physician when treating the PD patients [1] (World Health Organization, 2006). Thus exergaming can become can be an alternative to in-clinic sensory integration balance training (SIBT), as it can reduce postural instability in PD patients [23] (Gandolfi et al., 2017).

In recent years, exergaming training is a popular intervention, which is increasing rapidly in neurological rehabilitation [9] (Mirelman, Maidan, & Deutsch, 2013). In the world today, technology is advancing its growth in a fast pace, which allowed the capabilities of interface within digital technology to gradually enable people to have connection with computers easier than ever [14] (Jacob et al., 2008). Therefore, exergaming for balance training can provide easier access for PD patients. Different kinds of technologies include interfaces that requires interaction such as Wii Fit, Xbox sensor and virtual reality that bring elements of the real world [15] (Milgram & Kishino, 1994; [20] Simsarian & Akesson, 1997).

VI. LIMITATIONS AND FUTURE STUDIES

There were some limitations to this study. First, the studies identified to meet the eligible criteria was limited. Second, the review of the studies included many types of interventions, types of controls, measurement of results, and quality of methodologies. Third, considering that only published journal from three electronic databases, “Science direct”, “Pubmed” and “Scopus” were used and that the search terms were only limited to “exergaming,” “exergames,” “balance,” “Parkinson’s disease” “Virtual reality” and “Postural instability”. Finally, the search was limited to English publications, both publication bias and language bias can occur.

The results in this study may be used as a guide for future reference when designing exergaming balance training for future studies or rehabilitation application. As can be seen, the rehabilitation of the games and kits were games not designed specifically for adults with PD. Future studies may design games that focus on the needs of PD participants, including appropriate content, interface design and game needs. Future studies should indicate the standard measures of PD disease such as (Hoehn and Yahr ) [30] (Henrique, Colussi, & De Marchi, 2019; [25] Negrini et al., 2017).

| Author          | Outcome Indicator | Findings                                      |
|-----------------|-------------------|-----------------------------------------------|
| 1. Berg Balance Scale | Wii Fit balance board showed significant improvement such as balance and gait in PD participants. However, mood or confidence regarding balance showed no significance. |
The authors declare no conflict of interest.

INTEREST AND AUTHOR CONTRIBUTION
First author conducted the research, while second and third author analyzed the data. All of the authors wrote the paper and approved the final version of the paper.

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Yu-Feng Wu is a PhD student at the Graduate Institute of Sport, Leisure and Hospitality Management, National Taiwan Normal University. Mr. Wu’s main research interest includes organizational behavior, consumer behavior, sport wearables and game-based learning.

Jian-Hong Ye is a PhD student at the Department of Industrial Education, National Taiwan Normal University. He serves as research assistant at the Department of Industrial Education, National Taiwan Normal University. Mr. Ye’s main research interest includes digital learning, game-based learning, design education and vocational education.