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Can the Nintendo Wii be used as a More Effective Method of Rehabilitation than Traditional Physiotherapy Exercises for Patients with Knee Reconstruction Surgery?

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A SELECTIVE EVIDENCE BASED MEDICINE REVIEW

In Partial Fulfillment of the Requirements For

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In

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Department of Physician Assistant Studies
Philadelphia College of Osteopathic Medicine
Philadelphia, Pennsylvania

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ABSTRACT

OBJECTIVE: The objective of this selective EBM review is to determine whether or not the Nintendo Wii can be used as a more effective method of rehabilitation than traditional physiotherapy exercises for patients with knee reconstruction surgery?

STUDY DESIGN: Review of three English language primary studies, published after 1999.

DATA SOURCES: Two randomized controlled trials (RCTs) and one case study with no comparison group were found using PubMed. These studies analyzed Nintendo Wii intervention in patients that underwent knee reconstructive surgery in need of rehabilitation.

OUTCOME MEASURED: The outcome measured was improvement in balance through use of the Activity-Specific Balance Confidence Scale, center of pressure sway measured with stabilometry, and the Modified Star Excursion Balance Test. The tools used to assess significance of outcomes measured were p-values and change in mean from baseline.

RESULTS: All three studies demonstrated differing results with regard to the Nintendo Wii being used as a method of knee rehabilitation. The Fung et al study showed an insignificant improvement in balance confidence after rehabilitation ($p > 0.05$). The Puh et al study found that Wii therapy improved the balance of a single case patient with a change in mean from baseline of 59cm to 37.9cm, however a p-value was not available. The Baltaci et al study demonstrated an insignificant improvement in balance with use of the Nintendo Wii ($p > 0.05$).

CONCLUSIONS: The use of the Nintendo Wii as a more effective method of knee rehabilitation is inconclusive. All three studies demonstrated conflicting results. The Nintendo Wii may benefit as an adjunct therapy to be used along with traditional physiotherapy exercises.

KEY WORDS: Knee, rehabilitation, Nintendo Wii

INTRODUCTION

With an aging population and an overwhelming increase in the number of kids participating in youth sports, the number of knee reconstructive surgeries being performed is growing immensely. With young athletes starting to compete at very young ages, and training continuing to intensify, the tearing of ligaments within the knee as well as knee replacements later in life has become very common. This trend is predicted to continue for many years, along with the healthcare impact that goes along with it. “The number of revision total knee arthroplasties was 38,300 in 2005, and it is expected to reach 78,000 by 2015, and 268,200 by 2030 (a 600% increase).”¹

The Physician Assistant is going to become crucial in this field as the workload keeps increasing. The exact number of healthcare visits is not known, but it was found that “between 2000 and 2020, the demand for orthopedic services in this country will increase by 23% while the supply of orthopedic surgeons will increase by only 2%”.¹ The role of the PA therefore will have to expand to assist those surgeons. This includes both the repair as well as the rehabilitation process.

Reconstructive surgery can include a total knee replacement or a repair of the anterior or posterior cruciate ligaments, two of the main stabilizers of the knee joint in the sagittal plane.² The anterior cruciate ligament gets injured much more frequently than the posterior cruciate ligament in current athletes, but arthritis, tendinitis, and bursitis are the most common reasons former athletes require knee surgery.³ After years of constant impact, acceleration, and pivoting movements, the knee joint begins to lose its function.

After these major surgeries are performed, the rehabilitation process is essential for decreasing the rate of reinjures as well as for returning back to work or sport participation.⁴

Currently, the rehabilitation process for knee reconstruction is varied slightly from practice to practice with no standard agreement on the ideal treatment. Typical treatment has consisted of a range of physiotherapy exercises that allow the patient to slowly work their way up to full function of the knee. This includes weight bearing activity, resistive flexion and extension exercises, cycling, and balance activities.⁴

Recently however, studies have been looking at ways to utilize virtual reality as a way “to engage in multidimensional, multisensory virtual environments that appear to be comparable to real events.” One such method is with the Nintendo Wii, which is a “commercially available motion controlled video game system.”⁵ It has already been used in other therapeutic opportunities such as upper extremity and neurological rehabilitation because it is considered more entertaining than conventional exercise. The rehabilitation process could be more productive and dynamic if the patients were excited about completing it. Kids in particular could have a lot more fun while using the Wii as rehabilitation, therefore improving surgical outcomes.

It also offers a way to simulate sports and functional activities in a controlled environment without the increased risk of performing the actual activity. This could cut down the cost of reinjuries, as the current total cost for the United States is already \$18.75 billion in knee arthroplasties alone.¹ Although the Wii is a fairly inexpensive method of improving various orthopedic trends, few studies have been performed to discover the extent in which the Nintendo Wii can be used as sole therapy for total functional knee recovery.

OBJECTIVE

The objective of this selective EBM review is to determine whether or not the Nintendo Wii can be used as a more effective method of rehabilitation than traditional physiotherapy exercises for patients with knee reconstruction surgery.

METHODS

Three studies were analyzed in this review to include a population of both male and female patients that underwent knee reconstructive surgery and were in need of rehabilitation. Articles were chosen that utilized the Nintendo Wii as the rehabilitation intervention. Two of the articles were RCT's that compared the Wii to a control of traditional physiotherapy exercise as the form of rehabilitation. The third article was a case study, which had the patient only use the Nintendo Wii as her therapy. The outcome was measured in terms of balance of the affected knee post-rehabilitation.

Articles were all found on the PubMed database using the key words "Nintendo Wii", "rehabilitation", and "knee". They were all published in peer-reviewed journals in the English language and selected based on importance to patient-oriented outcomes (POEMS). The topic was researched due to interest in sports and orthopedics and the articles chosen were based on relevance to the clinical question. Studies that were included were published after 1999, two of which were RCTs. Articles were excluded if they were already systematic reviews posted on the COCHRANE database. Meta-analyses were also excluded. Studies that were excluded involved patients who did not undergo knee reconstructive therapy or those incapable of interacting with the Nintendo Wii.

A summary of the statistics reported includes p-value and change in mean from baseline.

Table 1: Demographics & Characteristics of included studies

| Study | Type | # Pts | Age (yrs) | Inclusion Criteria | Exclusion Criteria | W/D | Interventions |
|--------------------------------|-----------------------------|-------|----------------------|---|--|-----|--|
| Fung ⁵ (2012) | Randomized controlled trial | 50 | Avg 68 years old | Outpatient with full lower extremity weight bearing, requiring twice weekly physiotherapy tx for total knee rehab | - Active painful osteoarthritis in contralateral lower extremity - Uncorrected visual impairments -English language barrier or impaired ability to follow instructions | 0 | 60 minute physiotherapy session followed by 15 minutes of Wii fit gaming activities that incorporated lateral weight shifting, multidirectional balance, and static and dynamic postural control |
| Puh ² (2013) | Case study | 1 | 22 year old | Pt post PCL surgery in need of rehabilitation | - No previous knee injuries | 0 | Wii balance board training program for 6 days/wk for 4 weeks, each session lasting 30-45 minutes |
| Baltaci ⁴ (2013) | Double blind RCT | 30 | Avg 29 ± 7 years old | -Men who underwent unilateral arthroscopic ACL reconstruction using semitendinosus and gracilis grafts | -subjects with multiple injuries around the knee - hx of previous knee injury or neuromuscular disorder affecting motor coordination and perception | 0 | 1 hour sessions, 3 sessions per week for 12 weeks post surgery of 4 Nintendo Wii games (Bowling, Skiing, Boxing, Pro Series Football and Balance Board) |

OUTCOMES MEASURED

The outcome measured after rehabilitation with the Nintendo Wii was improvement in balance. Balance is considered a POEM because it affects the life of every patient. Simply the act of standing and walking requires balance. This is especially important in the elderly to prevent falls. Balance is very important for kids and adolescents too, especially if they wish to continue in sports. Running, jumping, kicking, and throwing all require balance and stability. Therefore, knee rehabilitation really needs to get the patients back to baseline.

Fung et al used the Activity-Specific Balance Confidence Scale (ASBCS) as a subjective way of measuring balance at the start of rehabilitation and then again at the end. This is a 16-item questionnaire that asks the patient for their confidence (in percentage) of doing certain activities without losing his or her balance. Total percentage score was then calculated. Student's t-test was used to find the mean percentage change from initial assessment to discharge.⁵

Puh et al measured balance objectively with stabilometry. A Kistler force platform with 50Hz sampling rate using the BioWare program was used to measure center of pressure (CoP) sway. The patient stood for 60 seconds on the injured leg, while the uninjured leg remained flexed at 90 degrees. This was done both on a firm and then compliant surface with her eyes open. The anteroposterior path length in cm was assessed both before the rehabilitation and then again after.²

Baltaci et al. also measured balance objectively but instead used a Modified Star Excursion Balance Test (SEBT). This test had the subject stand on one leg and reach posteromedial as far as they could with the other leg at a previously marked line. Both the healthy and reconstructed legs were measured at week 1, 8, and 12 of rehabilitation. The Mann-

Whitney U Test was used to determine group differences at each of the three weeks that the testing was performed.⁴

RESULTS

All three studies were before and after comparisons that investigated the Nintendo Wii as an effective way of knee rehabilitation. The two RCTs used traditional physiotherapy exercises as the control in which to compare the Wii intervention. The third study was a case study that only used the Wii as a way of rehabilitating the knee post surgery.

The data from all three studies were continuous and could not be converted into dichotomous data.

The RCT conducted by Fung et al. used 50 participants (17 males, 33 females) following total knee replacements. Average age was 68 years old. Those in the intervention group (n=27) participated in 60 minutes of physiotherapy exercises followed by 15 minutes of Wii fit gaming that incorporated lateral weight shifting, multidirectional balance, and static and dynamic postural control. Games were progressed as subjects' scores improved, and continued until each patient was individually discharged from the rehab facility. Nine different games were used in total. For safety reasons, a four-point walker was placed in front of all the participants while they played the games. This was used as needed to prevent falls. Those in the control group (n=23) participated in 60 minutes of physiotherapy exercises followed by 15 minutes of lower extremity strengthening and balance training exercises.⁵

Assessment of each participant was done at the first visit and then every 2 weeks until discharge. Data was collected in multiple ways to assess the entire function of the injured knee, but for the purpose of this review the outcome measured was limited to balance. This was achieved by using the Activity-Specific Balance Confidence Scale (ABCS). Results showed

there was no significant mean change from baseline for the interventional group compared to the control group ($p < 0.05$).⁵ Table 2 demonstrates these results.

Table 2: Change in balance confidence post rehabilitation

| Outcome Measured | Intervention with Nintendo Wii (n=27) | Control with physiotherapy only (n=23) | P-value |
|------------------|---------------------------------------|--|---------|
| ABCS | 48.24% | 34.13% | 0.523 |

Puh et al. performed a case study to investigate the rehabilitation options for a posterior cruciate ligament (PCL) that was repaired 12 weeks prior via arthroscopic surgery. The participant was a 22-year-old female with no other previous injuries. She participated in a Nintendo Wii balance board training program 6 days a week, for a total of 4 weeks. Each session lasted 30-45 minutes and included a variety of games. Sessions gradually increased in skill level and number of repetitions as time went on.²

Balance was assessed after the 4 weeks of Wii rehabilitation. This was done using stabilometry to calculate the center of pressure sway. Multiple parameters of postural sway were measured, but for this review, the anteroposterior path length was used because it challenged the PCL most. The stabilometry was performed on both a firm and compliant surface. P-values were not provided by the study, but the results of change in mean from baseline can be seen in Table 3.²

Table 3: Change in balance stabilometry in the anteroposterior path length

| Supporting Surface | Anteroposterior path length (cm) | | Percent mean change from baseline |
|--------------------|----------------------------------|-------|-----------------------------------|
| | Before | After | |
| Firm | 26.8 | 25.6 | 4.5% |
| Compliant | 59 | 37.9 | 35.8% |

Both surfaces showed a decrease in length, representing an improvement in overall balance. Without a p-value, however, it is difficult to say whether the Nintendo Wii caused significant improvement.²

Baltaci et al. conducted a double blind RCT which included 30 participants, average age of 29 years old. All participants underwent unilateral arthroscopic anterior cruciate ligament (ACL) reconstruction using semitendinosis and gracilis grafts. The same surgeon performed all 30 cases. Those in the intervention group (n=15) participated in 3 rehabilitation sessions a week for a total of 12 weeks post surgery. Each session lasted 1 hour and consisted of a combination of 4 Nintendo Wii games, which were chosen to help with physical and functional movement, cognitive functioning, and driving. Those in the control group (n=15) participated in physiotherapy exercises that gradually increased in intensity. The first 3 weeks included closed kinetic chain flexion and prone hanging exercises to help with knee flexion and extension, respectively. Straight leg raises were used to improve quadriceps strength. Cycling and balance exercises were incorporated in week 4, and finally jogging was allowed at week 12.⁴

A modified star excursion balance test (SEBT) was used to assess balance at the 1st, 8th and 12th week of rehabilitation. The healthy and injured legs were both measured in the posteromedial plane. This was done three times each and then averaged. The difference between the healthy knee and the injured knee was recorded in Table 4.⁴

Table 4: Difference in reaching distances between healthy and injured leg

| Direction | Group | 1st week X ± SD (min- max) | 8 th week X ± SD (min- max) | 12 th week X ± SD (min- max) | P | Difference between both groups |
|-----------------------|--------------|----------------------------------|--|---|-------|---|
| Posteromedial (cm) | Intervention | 3.5±3.2 (0.7-12.7) | 1.7±4.5 (- 8.3-7.4) | 3.1±6.9 (- 6.6-19.6) | 0.002 | > 0.05 n.s. |
| | Control | 5.7±4.3 (- 2.4-13.3) | 4.1±4.2 (- 0.7) | 5.5±5.3 (- 4.6-15.7) | 0.038 | |

Results showed that both groups separately demonstrated a significant improvement in balance as rehabilitation progressed. However, the difference between the two groups was not significant. Therefore, it is important to note that the Nintendo Wii can be comparable to conventional physiotherapy exercises for knee rehabilitation, but it cannot be considered more effective.⁴

The safety or tolerability of the intervention was not discussed by any of the three articles, however there are some health precautions put forth by Nintendo that should be taken into account when using the Wii. As with any video game, there is a small risk of seizures, repetitive motion injury, and eyestrain. This can be limited by standing as far away from the TV screen as possible, playing in a well-lit room, and taking a 10-15 minute break from playing every hour. TV screen damage can be prevented by utilizing the Wii Remote Strap correctly and consistently to avoid it slipping from the player's hand and hitting the screen.⁶

DISCUSSION

The combination of these three articles provided a solid base of information to help determine the efficacy of the Nintendo Wii as a method of knee rehabilitation. It helped to begin the framework for future research, but also presented many limitations and reasons for improvement.

The participants in the ACL study were described as “young and active individuals who might have had higher motivation of exercise and rehabilitation than other subjects with ACL injury”.⁴ This group could be considered outliers to the question being researched, as all patients recovering from ACL surgery may not be as motivated when rehabbing.

The Nintendo Wii has many advantages that make it ideal for knee rehabilitation once perfected. Its portability could allow patients to rehab right in the comfort of their home.² It is also very simple to use and not limited to any age. Therefore young kids with sporting injuries as well as the elderly with knee replacements can benefit. Lastly, the Wii can be purchased at a low cost, which allows for a greater population to access it. Currently, the Nintendo Wii can be purchased for \$100 or less.⁶

Virtual gaming systems have already been implemented for rehabilitation in patients with neurological diseases such as cerebral palsy and Parkinson’s.² It has helped with postural control, visuoperceptual processing, functional mobility, and balance. Part of its success could be due to the appropriate level of challenge and feedback information that the Wii provides.⁴ The clinician is able to adjust the game based on the individual ability of each patient and progress the rehabilitation appropriately and safely.

Being that this topic is relatively new, the minimal number of studies performed became a limitation. Ideally, three RCTs would have been used. The case study made it challenging to determine whether the Nintendo Wii was a more effective form a therapy since there was no control group in which to compare. The knee reconstruction surgery also would have been consistent throughout the three articles, as the rehabilitation may change slightly according to the surgery.

The studies each had their own limitations as well. Fung et al. mentioned that the participants were asked not to utilize the Nintendo Wii outside of the study. However, it is not possible to enforce this as many participants have access to the video game at their homes. A smaller sample size than intended was also mentioned, which could have negatively impacted the study.⁵ Puh et al. conducted his study 12 weeks after the participant underwent surgery. The long length of time between surgery and therapy could have affected the outcome. Any conventional therapy that took place before the Wii intervention was not controlled and therefore could not be analyzed. Lastly, there was no mention as to whether it was the right or left leg that was injured. Leg dominance could affect the outcome of PCL therapy in terms of strength and ability.² Baltaci et al. mentioned that the study took participants from only one clinic. All of the subjects were young (mean = 29 years old) and active, therefore more compliant and motivated to complete the therapy. Older participants may have changed the outcome of the study.⁴

CONCLUSION

The use of the Nintendo Wii as a more effective method of rehabilitation than traditional physiotherapy exercises for patients with knee reconstruction surgery is inconclusive. The conflicting results from the three studies cannot support the use of the Nintendo Wii as sole therapy at this time. It may be beneficial as an adjunctive therapy to traditional exercises.

Current studies are still being conducted to further investigate the Wii's ability to improve balance, specifically in stroke patients. Future studies could be created which just analyze children. A younger body may adjust better to the activities of video games and therefore be more ideal for this newer type of rehabilitation. Studies can also be done to further investigate the Nintendo Wii as therapy for other orthopedic conditions. Ankles, hips, and upper extremities may benefit to a similar degree.

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