IZMIR DEMOCRACY UNIVERSITY HEALTH SCIENCES JOURNAL
IDUHES
e-ISSN:2651-4575

IDUHeS, 2021; 4(3): 267-284
doi: 10.52538/iduhes.1012369

Araştırma Makalesi– Research Paper

THE EFFECTIVENESS OF NINTENDO WII ® EXERCISES IN REHABILITATION FOLLOWING KNEE SURGERY: A SYSTEMATIC REVIEW AND META-ANALYSIS

NİNTENDO Wİİ ® EGZERSİZLERİNİN DİZ CERRAHİLERİ SONRASINDA ETKİNLİĞİ: SİSTEMATİK DERLEME VE META ANALİZ

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Özet

Bu sistematik inceleme ve meta-analizin amacı diz cerrahisi geçirmiş hastalarda Nintendo Wii'nin (NW) etkinliğinin belirlenmesidir. Bu sistematik inceleme ve meta-analiz için literatür taramasında Cochrane Database of Systematic Review, MEDLINE (EBSCO), Physiotherapy Evidence Database (PEDro), CINAHL (EBSCO), PUBMED, OVID, Science Direct, Scopus, Academic Search Complete ve Google Scholar veri tabanları kullanılmıştır. Güncel çalışmaların dahil edilebilmesi için veri tabanı araştırması 2006 yılı ile 2021 yılı ağustos ayı arasıyla sınırlandırılmıştır. Tarih ve dil kısıtlamaları ile tarama gerçekleştirildi ve başlangıçta 203 ilişkili çalışmaya ulaşıldı. 41 çalışma başlangıç kriterlerini sağlayıp incelemeye dahil edilirken bu çalışmaların 4 tanesi nihai kriterleri sağladı. Tüm çalışmaların ortalama metodolojik kalitesi PEDro skalasına göre 10 üzerinden 4,25 olarak belirlendi. Meta-analiz standart fizyoterapi programına eklenen NW eğitiminin ağrıyı azaltma (SMD=-0.746; 95% CI=-1.333,-0.160; p = 0.013) ve fonksiyonellik (SMD=-0.744; 95% CI=0.260, 1.228; p = 0.003) üzerinde etkisinin sadece konvansiyonel fizyoterapiye göre istatistiksel açıdan daha etkili olduğunu göstermiştir. NW eğitimleri diz cerrahisi geçirmiş hastalarda ağrı, fonksiyonellik, denge, koordinasyon ve propriosepsiyon açısından umut vadeden bir araç olabilir. NW'nin etkinliğinin belirlenmesi için gelecekte yüksek kalitede çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Diz, Diz Replasman Artroplastisi, Anterior Cruciate Ligaman Yeniden Yapılandırılması, Video Oyunları, Sanal Gerçeklik Maruz Kalma Terapisi

Abstract

This systematic review and meta-analysis were aimed to determine the efficacy of Nintendo Wii (NW) in patients who have undergone knee surgery. In literature search of this systematic review and meta-analysis, Cochrane Database of Systematic Review, MEDLINE (EBSCO), Physiotherapy Evidence Database (PEDro), CINAHL (EBSCO), PUBMED, OVID, Science Direct, Scopus, Academic Search Complete, and Google Scholar databases were used. The database search was limited to the period from 2006 until August 2021 so as to capture more recent publications. The search strategy was applied with the limitation of date and language and this initial electronic search resulted in 203 relevant studies. Of these, 41 full-text articles met the initial criteria and were retrieved for review, with 4 studies meeting the final inclusion criteria. The mean methodological quality of all the studies was determined as 4.25 out of 10 on the PEDro scale. The meta-analysis indicated that NW training in addition to conventional therapy was statistically more effective than only conventional physiotherapy in reducing pain (SMD=-0.746; 95% CI=-1.333, -0.160; p = 0.013) and functionality (SMD=-0.744; 95% CI=0.260, 1.228; p = 0.003). NW training can be a promising tool on the pain, functionality, balance, co-ordination and proprioception of patients who have undergone knee surgery. There is a need for further studies of high quality to examine the efficacy of NW in rehabilitation.

Keywords: Knee, Knee Replacement Arthroplasty, Anterior Cruciate Ligament Reconstruction, Video Games, Virtual Reality Therapy

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1. INTRODUCTION

The knee is one of the most frequently injured joints in the body. Osteoarthritis of the knee and anterior cruciate ligament (ACL) injuries are often seen in the clinic (Günther et al., 1998, pp. 717-723 ; Miyasaka, Daniel, Stone, & Hirshman, 1991, pp. 3-8). To be able to restore the functions impaired by these problems, Total Knee Replacement (TKR) and ACL reconstruction surgery are widely used (Clapp, 2008, pp.348-358; Levinger et al., 2016, pp. 251-262; Negus et al., 2015, pp. 47-53). The main goals of rehabilitation following knee surgery increasing functionality and participation in daily living activities, sport or work. To achieve these goals managing pain, increasing strength and proprioception should be considered (Baltaci, Harput, Haksever, Ulusoy, & Ozer, 2013, pp.880-887).

Due to problems which have emerged because of prolonged length of stay in hospital and increasing quality expectations in the field of healthcare, researchers and clinicians are continually searching for new effective methods (Heick, Flewelling, Blau, Geller, & Lynskey, 2012, pp. 217-222). Virtual reality systems are a product of this search, and these have started to be used in recent years for rehabilitation. There has been an increasing number of studies made using Nintendo Wii ® (NW) which is an alternative virtual reality system (Levinger et al., 2016, pp. 251-262; Negus et al., 2015, pp. 47-53; Nitz, Kuys, Isles, & Fu, 2010, pp. 487-491). The greatest advantages of NW are its portable structure, the visual feedback provided and that it is inexpensive and easily accessible (Gunel, Kara, Ozal, & Turker, 2014, pp.273-301; Heick et al., 2012, pp. 217-222; Kim, 2005, pp. 119-146; Nitz et al., 2010, pp. 487-491 ; Wiemeyer & Kliem, 2011, pp. 41-50). NW might be used for managing pain, increasing strength, proprioception and reaction time in knee rehabilitation (Baltaci, Harput, Haksever, Ulusoy, & Ozer, 2013, pp.880-887).

The use of NW in rehabilitation is more common in the field of neurological physiotherapy. Although studies with NW are thought to be more appropriate for patients in the field of orthopaedic rehabilitation, there are few studies that have examined the effect of NW training in orthopaedic rehabilitation (Lange, Flynn, Proffitt, Chang, & “Skip” Rizzo, 2010, pp. 345-352; Puh, Majcen, Hlebš, & Rugelj, 2014, pp. 1124-1130). These studies have examined the effect of NW on different parameters (Baltaci, Harput, Haksever, Ulusoy, & Ozer, 2013, pp.880-887; Ficklscherer et al., 2016, pp.1273–1278; Fung, Ho, Shaffer, Chung, & Gomez, 2012, pp. 183-188; Negus et al., 2015, pp. 47-53 ; Puh et al., 2014, pp. 1124-1130). Nonetheless, there is no consensus on which parameters NW is effective on. This systematic review and meta-analysis were aimed to determine the efficacy of NW in patients who have undergone knee surgery.

2. METHODS

This systematic review and meta-analysis were conducted according to the principles of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, Altman, & Group, 2009, pp. 336-341).

2.1. Literature Search

The literature search used the following databases: Cochrane Database of Systematic Review, MEDLINE (EBSCO), Physiotherapy Evidence Database (PEDro), CINAHL (EBSCO), PUBMED, OVID, Science Direct, Scopus, Academic Search Complete, and Google Scholar. The search terms used in the databases were Wii, Wii fit, Wii balance board, Wii therapy, Nintendo Wii, Wii fit balance, Wii rehabilitation, Wii based movement therapy, Wii sports, knee, knee injury, knee pain, knee arthroplasty, knee replacement, knee joint, knee surgery, anterior cruciate ligament, posterior cruciate ligament, anterior knee pain, medial collateral ligament, lateral collateral ligament, menisci, quadriceps muscle, hamstring muscle, and cartilage. The database search was limited to the period from 2006 until November 2021 so as to capture more recent publications. Locally available physiotherapy journals were hand-searched.

2.2. Study Selection

To be selected for inclusion, a study had to:

- Be a randomized control trial, published in English.
- Involve patients who had undergone knee surgeries (studies were excluded if patients had multiple injuries around the knee or a neuromuscular disorder affecting motor coordination and perception).
- Investigate the effects of NW in the rehabilitation of knee surgeries.
- Use at least one outcome of pain, range of motion, muscle strength, balance and functionality with any outcome measurements.

Two reviewers independently applied the inclusion criteria to select potentially relevant studies from the title, abstracts and full-text articles, respectively. A consensus method was used to solve any disagreements concerning inclusion of studies. When in doubt, the full text of an article was read to determine its suitability and a third reviewer was consulted if disagreement persisted. The same eligibility criteria were applied to all the titles and abstracts identified during the search. The selection of studies comprised two steps. In the first step, titles and abstracts of studies were screened and irrelevant studies were removed. Potentially relevant full text studies were obtained for further evaluation regarding the inclusion criteria in the second step.

2.3. Methodological Quality Judgment

The quality assessment of the studies was conducted using PEDro. The PEDro scale is a checklist of 11 yes/no questions to appraise studies regarding allocation bias, blinding and adequacy of follow-up. A PEDro score out of 10 points reflects a study methodological quality based on the following classification: a PEDro score of 9-10 is considered to be excellent, a score of 6-8 is good, a score of 4-5 is fair, and a score of less than 4 is considered to be poor (Moseley, Herbert, Sherrington, & Maher, 2002, pp. 43-49). The quality assessment of studies was conducted by two reviewers using PEDro. A consensus method was used to solve any disagreements between the two authors and a third reviewer was consulted if disagreement persisted on the quality of trial.

2.4. Data Extraction

Relevant data was extracted from each study using a standardized data extraction form that contained bibliographic data (authors and years of publication), study characteristics (aim of the study, study design, and sample size), characteristics of participants (gender, age, and symptoms), and description of the intervention (both intervention and control groups), follow-up intervals, outcomes assessed and results.

2.5. Data Synthesis

During the data extraction and analysis, the authors assessed all four studies for clinical heterogeneity with respect to the participants, intervention and outcomes and they concluded that performing meta-analysis was only suitable for pain and functionality parameter with two studies (Fung et al. 2012, pp. 183-188 and Karakoc, Colak, Zubeyir, & Polat, 2019, pp. 124-129). Therefore, the rest of results were described narratively. The random effects model was used considering the variability in the populations and interventions. To obtain the pooled effects, a random-effects model was used since the I2 value was more than 30%. The forest plots displaying SMD and 95% CIs were used to compare the effects between intervention and comparison groups. SMDs were significant when their 95% CIs excluded zero, while pooled SMD values of less than ± 0.2, or ranging from ± 0.2 to ± 0.8 or greater than ± 0.8 indicated the existence of small, medium or large effects, respectively (DerSimonian & Laird, 1986, pp. 177–188). All statistical analyses were performed using Comprehensive Meta-Analysis (CMA) software Version 3 (CMA V3, Biostat Inc, NJ, USA).

3. RESULTS

3.1. Selection of Studies

The search strategy was applied with the limitation of date and language and this initial electronic search resulted in 203 relevant studies. After duplicates were removed, the titles and abstracts of 76 articles were screened. Of these, 41 full-text articles met the initial criteria and

were retrieved for review, with 4 studies meeting the final inclusion criteria. The flow of selection of the studies, and reasons for exclusion at the final stage, are summarized in a PRISMA diagram (Fig. 1).

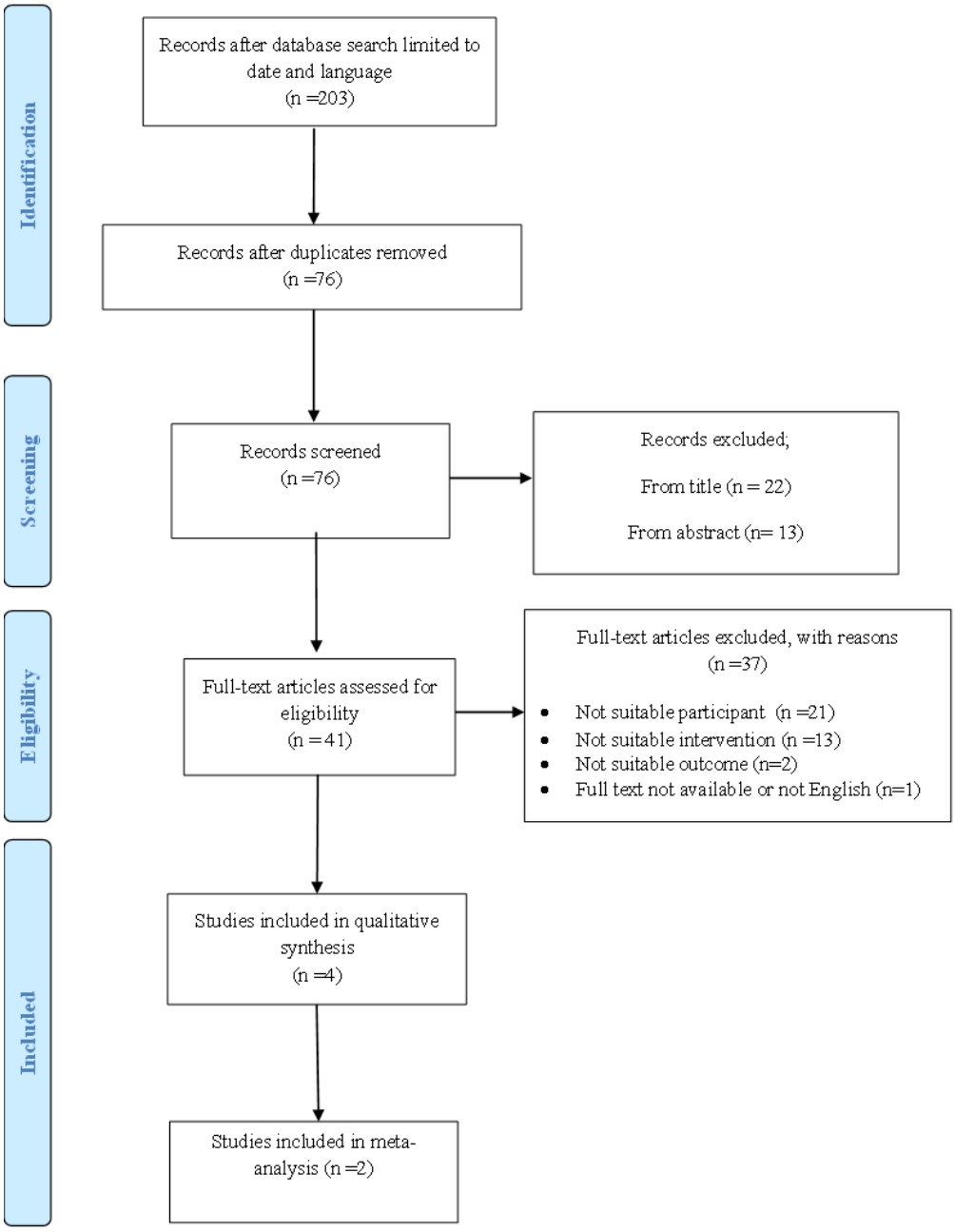

Figure 1. Prisma flow diagram

3.2. Quality Assessment

The methodological quality of the studies was assessed with the 11-item PEDro. The maximum score was 6 (Fung et al., 2012, pp. 183-188) out of 10 and the minimum score was 2 (Ficklscherer et al., 2016, pp.1273–1278) out of 10. The mean methodological quality of all the studies was 4.25 out of 10 on the PEDro scale. The results of the methodological quality scoring for all the included studies are shown in Table 1.

3.3. Description of Included Studies

The 4 studies included in this review from the electronic database search were 4 published RCTs. The characteristics of the included studies are presented in Table 2.

3.3.1. Participants

A total of 132 patients were enrolled in the included studies. The participants were male and female adults in the age range of 20s, 30s, 50s and 60s.

3.3.2. Interventions

The included studies used NW games (Bowling, Skiing, Deep Breathing, Soccer Heading, Ski Slalom, Tightrope Walk, Penguin Slide, Table Tilt, Hula Hoop, Half Moon and Torso Twist games and simple knee flexion/extension exercises).

3.4. Comparison Interventions

The comparison interventions were applied conventional physiotherapy exercises (prone hanging exercise, closed kinetic chain flexion exercise, straight leg raise, isometric quadriceps sets, cycling and balance exercise, balance exercise, posture exercise, weight shifting exercise, strengthening exercise and weight bearing exercise).

3.5. Outcome Measures

The outcome measures were Center of Gravitiy (COG), Balance Score, Star Excursion Balance Test (SEBT), Functional Squat Test, Knee flexor and extensor muscle strength, Response time, Active Range of Motion, 2-Minute walk test (2MWT), Numeric Pain Rating Scale (NPRS), Lower Extremity Functional Scale (LEFS), Activity Specific Balance Confidence Scale (ABCS), and International Knee Documentation Committee Score (IKDC).

The efficacy of NW training in addition with conventional physiotherapy programs after knee surgery was compared in all the studies included in this systematic review. However, the efficacy of NW training was only examined in one study.

Table-1: Scoring of the methodological quality of included studies using PEDro

Study	*1. Eligibility criteria*	*2. Random allocation*	*3. Concealed allocation*	*4. Baseline comparability*	*5. Blinding subject*	*6. Blinding therapist*	*7. Blinding assessor*	*8. Outcome Data> 85%*	*9. Intention to treat*	*10. Between Group results*	*11. Point measure/ measures of variability*	*PEDro score*
Baltaci et al, 2013	N	Y	N	Y	N	N	N	N	Y	Y	Y	5
Fung et al, 2012	Y	Y	N	Y	N	N	Y	N	Y	Y	Y	6
Ficklscherer et al, 2016	N	N	N	Y	N	N	N	N	N	N	Y	2
Karakoc et al, 2019	N	Y	N	Y	N	N	N	N	N	Y	Y	4

Table-2: Overview of Included Studies

Study	Aim	Population	Intervention/ Comparison	Follow Up	Outcomes	Results
Baltaci et al, 2013	To investigate whether Nintendo Wii Fit is an effective tool on the subjects with anterior cruciate ligament reconstruction and then compare the outcomes, including knee strength, balance, coordination, proprioception and response time, between Nintendo Wii Fit group and rehabilitation group.	N=30 Wii Fit group n=15 Mean age: 28.6 years Conventional group n=15	*Wii Fit group:* The bowling and skiing games in Wii sports, Boxing, Football and Balance Board within Sports Pro Series (Each game were tried for 15 minutes. 3 sessions (each session lasted 1 hour) per week. *Conventional group:* Prone hanging exercise, closed kinetic chain flexion	At first week, 8th and 12th week	Dynamic balance testing (modified star excursion balance test), functional squat test (coordination, balance and response time were assessed by using functional squat system), knee flexors and extensors muscle strength (isokinetic dynamometer)	Nintendo Wii Fit provided a significant development in dynamic balance and proprioception following ACL reconstruction surgery. Besides, there was no significant difference between Wii Fit and conventional group in terms of isokinetic knee strength at 12th week, and dynamic balance, and functional squat tests including coordination, proprioception, and response time at first, 8th and 12th weeks of the rehabilitation.

		Mean age: 29.3 years	exercise, straight leg raise, isometric quadriceps sets, cycling and balance exercise were applied.			
Ficklscherer et al, 2016	To examine whether the Nintendo Wii is an appropriate and safe tool in rehabilitation after orthopaedic knee surgery (anterior cruciate ligament surgery and total knee arthroplasty).	N= 30 Wii fit group n=17 Mean age: 54 years Control group n=13	*Nintendo Wii Group:* Simple knee flexion/ extension exercises were tried 10 minutes or until fatigue of the test subject in addition to standard physiotherapy sessions. 3 daily sessions were applied. *Control Group:* Full weight bearing and standard physiotherapy alone. No detailed information. 3 daily sessions were applied.	Preoperatively, before discharge and 4 weeks after surgery	International Knee Documentation Committee score, the modified Cincinnati Rating System and the Tegner Lysholm Knee Score.	There was no significant difference in the functional score between the Nintendo Wii and control group.

		Mean age: 52 years				
Fung et al, 2012	To determine whether Nintendo Wii Fit is an acceptable adjunct to physiotherapy treatment in the rehabilitation of balance, lower extremity movement, strength and function in outpatients following total knee replacement	N=50 Wii Fit group n=27 Mean age: 67.9 years Control group n=23	*Wii Fit group:* 15 minutes of following Wii Fit Deep Breathing, Ski Slalom, Tightrope Walk, Penguin Slide, Table Tilt, Hula Hoop, Half Moon, Torso Twist games in addition with 60 minutes physiotherapy sessions (active and passive knee stretching, lower extremity strengthening and balance exercise.) *Conventional group:* 15 minutes balance, posture, weight shifting and	At baseline and every 2 weeks thereafter until they were discharged from physiotherapy services	Active range of motion, 2-minute walk test, Numeric Pain Rating Scale, Lower Extremity Functional Scale, Activity-specific Balance Confidence Scale and patient satisfaction.	There was no significant differences in pain, knee flexion, knee extension, walking speed, timed standing tasks, lower extremity functional scale, Activity-specific Balance Confidence Scale, and patient satisfaction with therapy services between Wii Fit and conventional group.

		Mean age: 68.2 years	strengthening exercises in addition with 60 minutes physiotherapy sessions (active and passive knee stretching, lower extremity strengthening and balance exercise.)			
Karakoc et al, 2019	To investigate the effectiveness of Nintendo Wii© balance games added to the accelerated rehabilitation program after ACL reconstruction	N= 22 Wii fit group n=14 Mean age: 31 years Control group n=8 Mean age: 24 years	*Nintendo Wii Group:* Nintendo Wii© balance games were added to the rehabilitation program of the Nintendo group in the 4th week. These games lasted 40 minutes after the main rehabilitation program, and the patients were given a 10 minute rest period before starting the Nintendo Wii© balance games. Each of the soccer heading, skiing, table tilt and penguin slide games placed in the Nintendo Wii© game console were played for 10 minutes. In the	At baseline, 3^{th} and 6^{th} week	Pain (Visual Analog Scale), Lower Extremity Functional Score, The Center of Gravity (with Nintendo Wii© balance board) and Balance (with Nintendo Wii© balance board)	There was no significant differences in pain, lower extremity functional scale, the center of gravity and balance between Nintendo Wii© and control group.

			last week of the virtual rehabilitation program, the difficulty levels of the games were increased. *Control Group:* The rehabilitation program was divided into four phases. Phase 1 included edema and pain control, and increasing range of motion; Phase 2, weight-bearing and strengthening exercises (thera-band ® exercises); Phase 3 and 4 strengthening exercises progressed and functional and balance exercises (with rocker board). The sessions were individual and lasted for 45 minutes, 3 times a week for 6 weeks.			

N: number of cases in the study, **n:** number of cases in the groups, **ACL:** anterior cruciate ligament

3.6. Meta-Analysis

Meta-analysis was conducted for pain and functionality parameter with only two studies (Fung et al. 2012, pp. 183-188 and Karakoc et al., 2019, pp. 124-129). When assessing the impact of NW in addition to conventional physiotherapy on pain intensity, the pooled results of the interventions included in the meta-analysis (Fig. 2) showed that the wii fit group was statistically more effective than control group (SMD=-0.746; 95% CI=-1.333, -0.160; p = 0.013). The medium effect size (ES=0.746, p = 0.013) indicated a moderate favourable effect of NW training in addition conventional physiotherapy on pain intensity in patients following knee surgery. Regarding the effectiveness on functionality measured with LEFS, the pooled results of the interventions included in the meta-analysis (Fig. 3) showed that the Wii fit group was statistically more effective than control group (SMD=-0.744; 95% CI=0.260, 1.228; p = 0.003). The medium effect size (ES=0.744, p = 0.003) indicated a moderate favourable effect of NW training in addition conventional physiotherapy on pain intensity in patients following knee surgery.

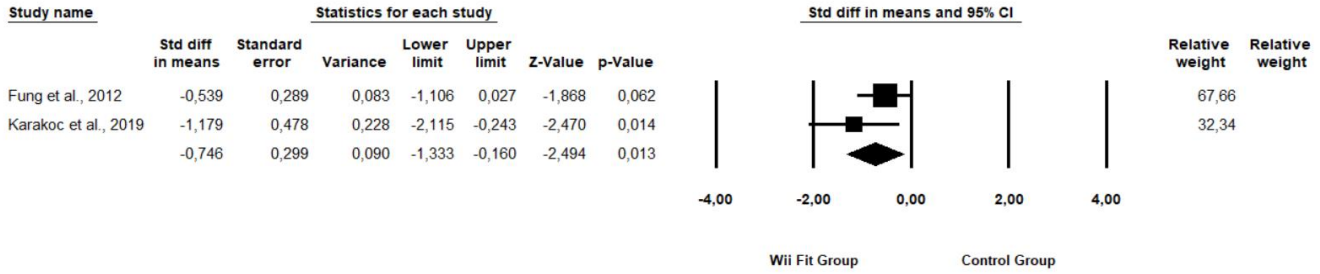

Figure 2. Meta analysis for pain intensity

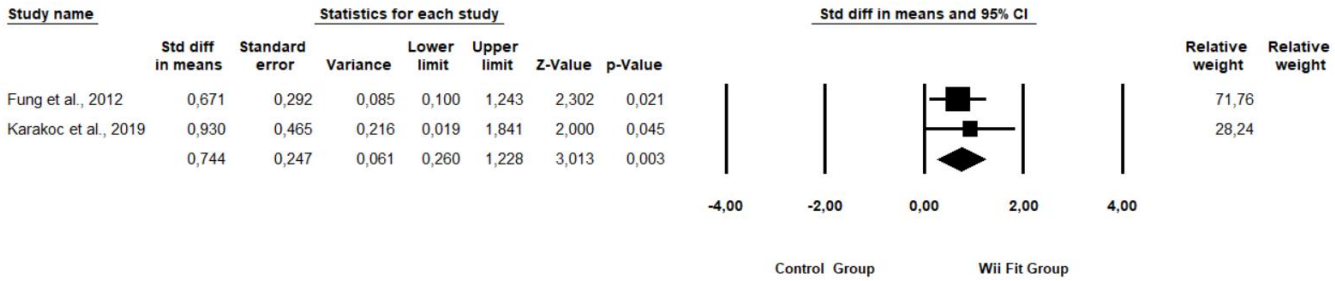

Figure 3. Meta analysis for functionality (LEFS)

3.7. Narrative Synthesis

Baltaci et al. (Baltaci et al., 2013, pp.880-887) found that SEBT, coordination and proprioception test results significantly differed depending on time. For both groups, the

anterior division of showed significant differences between the 1st and 8th weeks (Wii: p=0.004, Con: p=0.039) and between the 1st and 12th weeks (Wii: p=0.019, Con: p=0.016) of the rehabilitation. Similarly, the posteromedial division of SEBT also showed a significant difference in both groups between the 1st and 8th weeks (Wii: p=0.004, Con: p=0.005) and between the 1st and 12th weeks (Wii: p=0.006, Con: p=0.02) of rehabilitation. There was determined to be a significant difference in the coordination test between the 1st and 8th weeks of the rehabilitation in the Wii group (p=0.017). The proprioception test including deviation first movement deficit was recognized as significantly different in both groups between the 1st and 12th weeks of the rehabilitation in this study (Wii: p=0.032, Con: p=0.012). No difference was reported in either group in the 1st, 8 and 12th weeks of the rehabilitation in terms of response time and the time to finish, which are parts of the response time test, or in flexion and extension strength in respect of peak torque and total work at 60/s and 180/s angular velocities in the isokinetic test ($p<0.05$). In the Wii group, while the flexion strength in peak torque at 180/s reached 73.6 %, at 60/s it reached 76.6 %, and the extension strength in peak torque at 180/s reached 69.6 %, whereas 64.4 % was reached at 60/s. In the conventional group, while the flexion strength in peak torque at 180/s reached 88 %, at 60/s it reached 70.7 %, and the extension strength in peak torque at 180/s reached 61.5 %, and 64.9 % was reached at 60/s.

Baltaci et al. (Baltaci et al., 2013, pp.880-887) found no significant difference between the Wii and conventional groups in respect of isokinetic knee strength, dynamic balance, and functional squat tests including coordination, proprioception and response time in the 1st, 8th and 12th weeks of the rehabilitation ($p>0.05$). Moreover, Karakoc et al. reported that there was no significant difference between the Wii and conventional groups on the balance in the baseline, 3rd and 6th week (p= 0.372, 0.754 and 0.593).

According to Karakoc et. al. (Karakoc et al. pp. 124-129), the COG asymmetry improved statistically significantly in the Nintendo group (p= 0.006), after 6 weeks of rehabilitation, but the change in the control group was not statistically significant (p= 0.106). The changes in the COG positioning were compared between the two groups, and there were no statistically significant differences in any of the assessment results (p= 0.277, 0.717, 0.707) (Table 2). However, at the end of the treatment, the location of the COG was statistically symmetrical in both groups (p= 0.345 and 0.944).

Ficklscherer et al. (Ficklscherer et al., 2016, pp.1273–1278) compared NW and conventional therapy in respect of functional testing scores. Even though the results showed a slightly greater improvement of the Wii group, no statistically significant difference was determined between the two groups ($p>0.05$).

Fung et al. (Fung et al., 2012, pp. 183-188) reported no difference between the groups in objective measures of percentage change from admission to discharge in respect of active knee flexion (p=0.951), active knee extension (p=0.492) and distance covered in the 2MWT (p=0.855). Subjectively, there was no difference in changes ABCS scores (p=0.523) between

the groups. No difference was found between participants requiring a longer length of outpatient rehabilitation (>6 weeks) compared with those discharged within the expected timeframe (≤6 weeks). Patient satisfaction with therapy services did not differ between the two groups (p=0.201).

4. DISCUSSION

The aim of this study was to determine the efficacy of NW training on rehabilitation following knee surgery. As a result of the literature search, of 203 studies examined, 4 of studies met the criteria and were included for evaluation. According to the meta-analysis of two studies, NW training has a significant effect on the pain and functionality parameters. Besides, NW training can be a promising tool on the balance, co-ordination and proprioception of patients who have undergone knee surgery regarding narrative synthesis. However, there was no evidence about the effectiveness of NW training on the reaction time and muscle strength parameters.

According to the results of Baltaci et al. (Baltaci et al., 2013, pp.880-887), NW training provided a significant development in dynamic balance and proprioception following ACL reconstruction surgery (Baltaci et al., 2013, pp.880-887. In another study, 6 weeks of NW training were administered to a case after posterior cruciate ligament reconstruction and at the end of the training period, there was reported to be a significant improvement in balance (Puh et al., 2014, pp. 1124-1130). This was consistent with the results of the study by Baltaci et al. (Baltaci et al., 2013, pp.880-887). In NW games played with a remote control, the sensory input in the lower extremities is increased (Heick et al., 2012, pp. 217-222). The increase in balance and proprioception is thought to occur through the sensory input provided by the NW training.

Baltaci et al. (Baltaci et al., 2013, pp.880-887) reported a significant increase in co-ordination after NW training. In addition to movement and weight bearing, exercises made with NW require sensitive co-ordination skills. In games played on the balance board, the appropriate severity, direction and duration of weight bearing are necessary. These are the primary factors in the development of co-ordination.

In the same study it was reported that there was no significant effect of NW training on isokinetic muscle strength and reaction time parameters. This result is thought to be associated with the games selected for NW training. Although the occurrences of intermittent compression forces are provided with different contractions in the lower extremity, there is nothing in the nature of these games that could increase knee flexion and extension forces. The high mean muscle strength of the participants with a significant increase seen in the muscle strength of the control group was thought to be due to the sample being young adults.

Generally, an improvement in reaction time can be expected associated with the structure of the game of the exercises made with the balance board and selected for the lower extremity. Furthermore, this result could be due to the evaluation of reaction time in the sagittal

plane following exercises made in the frontal plane with NW. In another study, NW games were used which were played with multi-directional weight bearings. According to the results of that study, a significant improvement was seen in reaction time following NW training (Cone, Levy, & Goble, 2015, pp.7011-715).

In a study by Fung et al. (Fung et al., 2012, pp. 183-188) of TKR patients, in one group NW training was added to the standard physiotherapy program and in the other group, balance and strengthening exercises. At the end of the study, the functional evaluation scales, pain, range of movement and 2MWT results were reported to be similar in both groups. The similarity between the groups was thought to be due to the differences in the program only constituting 15 mins of a 75-minute physiotherapy session.

According to the results of the study by Baltaci et al. (Baltaci et al., 2013, pp.880-887, no difference was determined between the standard physiotherapy group and the NW group in respect of dynamic balance, proprioception, co-ordination, muscle strength and reaction time parameters. A great similarity was found in the exercises in the games with NW and the exercises used in rehabilitation after ACL surgery. Closed kinetic chain exercises which are usually preferred in rehabilitation are repeatedly made with the NW games played with weight bearing. During NW training, the lower extremity muscles work as stabilisers against the oscillations of the upper body by isometric contractions. The counterpart of NW balance games are balance and coordination exercises in rehabilitation. Therefore, it is to be expected that there would be no difference between the two groups in respect of the relevant parameters.

According to meta-analysis of two studies, NW training in addition conventional physiotherapy has superior than only conventional physiotherapy on pain and functionality parameters. However, Ficklscherer et al. (Ficklscherer et al., 2016, pp.1273–1278) found that there was no significant difference between the two groups in respect of the functional scales. This conflict results might stemmed from the low level of quality (poor eligibility criteria, randomising protocol and blinding process) of Ficklscherer et al. study'.

The NW training methods used in the studies included in this study and the outcome measurements were different from each other. In each study, there were different groups of participants, and different games, duration and methods were used. Therefore, that the included study results could not be examined together is one of the limitations of this study. Other limitations are the low number of studies included and the limited size of the samples. In addition, only one of the studies had evidence of a good level, one was of a moderate level and the other presented a weak level of evidence.

5. CONCLUSION

In conclusion, NW training has a significant effect on the pain and functionality parameters. Besides, NW training can be a promising tool on the balance, co-ordination and proprioception of patients who have undergone knee surgery regarding narrative synthesis. However, there was no evidence about the effectiveness of NW training on the reaction time and muscle strength parameters. There is a need for further high quality studies regarding blinding and randomising process to examine the efficacy of NW in rehabilitation.

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