Wii Fit™ Age in older adults undergoing total hip arthroplasty: a preliminary study

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ABSTRACT:

Background:
Wii Fit has potential applications in rehabilitative and preventative medicine; however, the prognostic value of the Wii Fit Age (WFA) parameter has not been explored. WFA is derived from the player’s weight, height, age, and balance scores. This study assesses changes in WFA in total hip arthroplasty (THA) patients as a gross estimate of hip function.

Methods:
THA participants were aged ≥50 undergoing THA with no experience using Wii Fit. The control group met identical criteria without hip pathology. Both groups were assessed at 3 temporally spaced sessions. Each session consisted of a baseline Wii Fit Age (WFA1) assessment, followed by 3 Wii Fit Exercises (Soccer Heading, Penguin Slide, Hula-Hoop) and then a post-exercise Wii Fit Age assessment (WFA2). Past medical history and the Western Ontario and McMaster Universities Arthritis Index (WOMAC) were completed.

Results:
Seventeen participants were recruited for the study (8 THA group and 9 control). Five THA participants were lost to follow-up by Session 3. WFA1 decreased across sessions for both THA and control groups, but the decrease was not significant. WFA2 was consistently lower than WFA1 for both groups. There were no significant inter-sessional differences in WFA1 or WFA2 for either group. Multiple regression analysis revealed WOMAC scores were never a significant predictor of WFA for either group at any time. There were no significant differences in Soccer Heading or Penguin Slide scores between or within groups. Scores for Super Hula-Hoop were significantly higher in the control group in Session 1 (p=0.042) but not in Sessions 2 or 3 (p=0.792; p=0.105).

Conclusion:
This pilot study does not support the use of Wii Fit Age nor any of the undertaken exercises as definitive prognostic tools. Further research with larger cohorts is needed.
INTRODUCTION

In 2010, 42,713 Canadians underwent a hip arthroplasty procedure, representing an increase of ~11% compared with 2006 [1]. Of these hip replacements, 10% were revision arthroplasties performed mostly for aseptic loosening [1]. The majority of hip arthroplasty patients are aged 65 to 74; however, the rates of hip surgery in younger patients are increasing with 29.6% of all hip arthroplasties currently performed in patients aged 45 to 64 [2]. These increases in national hip replacement surgery necessitate appropriate longitudinal post-operative follow-up.

At Queen’s University affiliated hospitals, routine postoperative follow-up for hip arthroplasty occurs at 6 weeks and 3 months. However, these patients often rely on others for transportation. Attending follow-up appointments presents a challenge, especially for individuals in remote settings. Additionally, the tools to assess post-operative hip function, such as comprehensive physiotherapy evaluations and gait analysis, are time and resource intensive. An inexpensive and portable means of evaluating post-operative hip function is desirable for implementation in rural and primary care settings.

Active video game systems controlled through movement, such as the Nintendo Wii™ gaming console, have gained popularity in the health sector. Created in 2006, the Wii™ gaming system revolutionized virtual reality by allowing interactive gameplay via an infrared motion-detection system combined with a handheld remote control device with built-in 3D accelerometer technology. The system responds to changes in the handheld controller’s direction, speed and acceleration. The Nintendo Wii Fit™ Plus game is paired with a wireless Bluetooth™ balance board allowing 60 hours of play time with 4 AA batteries. The balance board has 4 strain gauge load sensors (1 positioned in each corner) to estimate centre of gravity and track movements via weight shifting. At a basic level, the Wii Fit™ balance board resembles pressure plate systems currently used in gait labs.

The Wii Fit™ Plus system has been evaluated for its use in depression [3], neurogenic [4,5] and muscular [6,7] rehabilitation, fall risk assessment [8] and fall risk reduction [9-12]. However, few have investigated its use in joint replacement surgery [13,14]. One preliminary randomized controlled trial investigated Wii Fit™ as an adjunct or replacement to physiotherapy in total knee replacements [15]. Wii Fit™ was found to be an acceptable adjunct – but not replacement – for guided physiotherapy in this population. Even fewer studies have assessed the validity and reliability of Wii Fit™ scores [10,16]. One such study found the Basic Step exercise to demonstrate reliability and discriminant validity in the assessment of fall-related risk [17].

Within the Nintendo Wii Fit™ Plus system is a measurement called the Wii Fit Age (WFA). WFA is a computed virtual age based upon the player’s actual age, body mass index (BMI) and balance. Balance is scored after performing a Basic Body Test. This study assesses whether there is a correlation between WFA and postoperative changes in hip function after total hip arthroplasty (THA). The study also evaluated select exercises including Soccer Heading, Penguin Slide, and Super Hula-Hoop.

METHODS

i. Patient Selection

This study was approved by the Queen’s University Research Ethics Board. Informed consent was obtained from all participants. The study was conducted from June 2013 to November 2013 in the outpatient clinic at Hotel Dieu Hospital in Kingston, Canada under the supervision of a medical student or orthopaedic surgery resident. Total hip arthroplasty patients, representing the THA group (n=8), were recruited during their preoperative anesthesia visit. Patients were eligible if they were over the age of 50 with adequate vision and hearing, and no experience using the Wii Fit™ Plus system within the past year. Control participants, recruited through local organizations, were age-matched and had no known history of hip pathology. THA participants were withdrawn if they developed post-operative medical or infectious complications.

ii. Instrumentation

The Nintendo Wii Fit™ Plus system (Nintendo of Canada, Inc) and its balance board were used to assess balance function. The THA group was first assessed pre-operatively (Session 1) and then at 6 weeks and 5 months post-operatively (Sessions 2 and 3, respectively). The control group completed three sessions at 1-week intervals to prevent training and repetition-related improvement. The sequence of exercises is shown in Figure 1. All participants initially performed a Basic Body Test, used to compute the first Wii Fit Age (WFA1). Next, participants performed three Wii Fit exercises selected for their motion at the hip joints and balance requirements: Soccer Heading, Penguin Slide, and Super Hula-Hoop. In Soccer Heading, participants move their centre of gravity to strike oncoming soccer balls while avoiding distractors. Penguin slide involves laterally shifting one’s centre of gravity to catch fish jumping on to an iceberg. In Super Hula-Hoop, participants must rotate their hips in large clean circles at a fair pace while occasionally leaning left or right to catch additional hula-hoops. Soccer Heading and Penguin Slide exercises were completed 3 times each and scores averaged. Super Hula-Hoop was done once because it was more physically demanding. After all exercises were completed, the Basic Body Test was repeated and the second Wii Fit Age (WFA2) was recorded. Following each session, participants completed the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)
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Hip Score. The WOMAC is a standardized questionnaire used to assess osteoarthritis by asking participants to subjective rank pain, stiffness, and functional limitation. It is sometimes used to assess the need for arthroplasty. The total assessment was 45 minutes in duration.

**iii. Statistical Analyses**
The data was analyzed using Statistical Package for Social Sciences Version 21 (IBM Corp., New York, USA). Chi-square, Mann-Whitney U and independent sample T-tests were run to compare descriptive statistics (age, height, weight, physical activity) between THA and control groups. Sample T-tests compared Wii Fit Age and exercise scores between groups. A multiple regression analysis was performed to determine if changes in Wii Fit Age correlated with WOMAC scores. An alpha <0.05 was considered significant.

**RESULTS**

**i. Patient Demographics**
Eight participants (6 female, 2 male) with an average age of 72 (range 60-88) were recruited as THA participants. Two were lost to follow-up for Session 2 and an additional 3 were lost for Session 3. Study participants withdrew due to transportation restrictions and difficulty accommodating the length of the session into their schedule. Nine individuals (5 female, 4 male) with an average age of 68 (range 51-81) volunteered as control participants, and none were lost to follow-up. The groups did not differ significantly in demographics.

**ii. Wii-Fit Age**

For the control group, mean WFA2 was lower than WFA1 in all 3 sessions (Fig. 2A). These decreases were not significant except for Session 1 where the mean WFA1 was 68.9 ± 2.5 (mean ± SE) and WFA2 was 62.6 ± 5.2 (p=0.01). WFA1 did not differ significantly between Sessions 1 and 2 (p=0.98), or Sessions 2 and 3 (p=0.55).

For the THA group, mean WFA2 was lower than WFA1 both pre- and post-operatively (Fig. 2B). However, this trend was only significant at Session 2 where the mean WFA1 was 65.2 ± 3.1 and mean WFA2 was 53.8 ± 7.2 (p=0.02). There were no significant differences in WFA1 from Sessions 1 to 2 (p=0.22), or between Sessions 2 and 3 (p=0.98).

Comparing WFA results between the THA and control groups using independent samples T-tests revealed no significant differences in WFA1 or WFA2 at any time.

**iii. WOMAC Scores**

The mean WOMAC score for the control group was 92.6 ± 4.3 (Fig. 3). Inter-sessional WOMAC scores did not change for the control group, as participants noted no change in hip function. THA group WOMAC scores increased with each session. Session 1, 2 and 3 WOMAC scores for the study group were 72.4 ± 4.5, 84.2 ± 4.5, and 85.7 ± 8.5 respectively. No increases in mean WOMAC scores were significant for the THA group (p=0.21; p=0.99). WOMAC scores were significantly different between THA and control groups at Session 1 (p=0.01), but this significance was lost for Sessions 2 and 3 (p=0.22; p=0.46). A multiple regression analysis revealed that the WOMAC score was never a significant predictor of WFA in either group at any session (p=0.26; p=0.53; p=0.79).
In-Game Exercises

In the Soccer Heading exercise, mean scores increased with each session for both the THA and control groups (Fig. 4). The largest increase was seen in Session 3 for the control group, where the mean score increased from 16.7 ± 3.7 in Session 2 to 32.3 ± 11.0 in Session 3; however, this increase was not significant (p=0.27). No other differences in mean Soccer Heading scores between sessions were significant for either the THA or control groups, respectively. Mean Soccer Heading scores were not significantly different between groups at any session (p=0.09; p=0.40; p=0.09 for Sessions 1-3 respectively).

For the Penguin Slide exercise, mean scores increased with each session for both the THA and control groups (Fig. 5). These inter-session increases were never significant in either group. In addition, comparative analysis between THA and control group at each session failed to detect statistical differences in Mean Penguin Slide scores (p=0.61; p=0.15; p=0.65 for Sessions 1-3 respectively).

For the Super Hula-Hoop exercise, mean scores increased between sessions for the THA group (Fig. 6A). However, these increases were not significant (p=0.60 [Session 1 vs. 2]; p=0.81 [Session 2 vs. 3]). Control group Super Hula-Hoop scores decreased from 71.0 ± 16.8 in Session 1 to 55.8 ± 28.2 in Session 2 (below that of the THA group), only to increase in Session 3 to 85.2 ± 36.1. The fluctuation in control group Super Hula-Hoop scores was never significant (p=0.92; p=0.74). The control group’s mean Super Hula-Hoop scores were significantly higher than the THA group’s scores in Session 1 (p=0.04) but not in Sessions 2 or 3 (p=0.79; p=0.10). Figure 6B shows the individual and mean pre-operative Super Hula-Hoop scores for the THA and control groups.

DISCUSSION

The Wii Fit™ Plus system allows direct visualization and objective quantification of hip function post-THA. Gait labs accomplish this with great accuracy, however, lengthy wait times, cost and limited access are deterrents. The Wii Fit™ Plus system is an appealing option given its affordability, portability, and applicability to various healthcare sectors [17]. Wii Fit™ is also feasible and enjoyable in the older adult population [19,20].

The primary outcome WFA encompasses age, BMI and balance results from the Basic Body Test. In this study, WFA was measured before and after other exercises to determine the parameter’s reproducibility and objectivity. WFA2 always trended lower than WFA1 in both groups, though only significantly in Session 1 for the control group. Since age and BMI are constant variables, this suggests balance improved after completing the additional exercises. WFA2 is likely amenable to training and is an unsuitable objective measure of hip function. Furthermore, the process of obtaining WFA2 is not standardized. Whereas all participants complete a common Basic Balance test in the first Basic Body Test, the repeat test randomizes participants to 2 out of 10 activities. Some assess parameters other than balance like memory and visual acuity.
WFA1 was expected to remain relatively constant in the control group since hip function was stable. A decreasing WFA1 would suggest training-related improvement. WFA1 was constant at a mean of 68 years for Sessions 1 and 2 in the control group, and then decreased to 63 years for Session 3. These were not significant changes so WFA1 shows potential as an objective measure for hip function. In the THA group, WFA1 decreased from 73.5 years to 66 years post-operatively by Session 3. While also not significant, this downward trend may suggest WFA potential to detect balance improvements following THA. Further evaluation with a larger cohort is required.

To assess the validity of the WFA1 score, a multiple regression analysis assessed the correlation between changes in WOMAC scores with THA group changes in WFA across sessions. It was found that WOMAC scores were not a predictor of WFA1 at any point. This may be related to the study’s low power. At this point, WFA1 does not show adequate delineation of hip function either pre- or post-operatively. In a study of 45 active adults, Wikstrom (2012) similarly found that Wii Fit activities, including the basic balance test, had poor intra-session and inter-session reliability with minimal detectable change in scores relative to the mean [12]. Wikstrom did not recommend the use of Wii Fit balance scores as objective measures of progress [12]. However, modifications in study design may more accurately assess balance scores as objective measures. Such modifications include a larger sample size with a lower minimum age and earlier post-operative follow-up to better characterize trends in WFA.

Of the undertaken exercises, Soccer Heading and Penguin Slide appear least useful. An ideal objective exercise shows post-operative increase in THA group scores with only conservative increases (if any) in control group scores. Both exercises show steadily increasing scores for both groups. Most notable is the near doubling of the mean Soccer Heading score in Session 3 for the control group. This sharp increase, and narrow standard error, suggests Soccer Heading is highly susceptible to training. The Soccer Heading activity also depends more on visual acuity and reaction time rather than balance. Participants often could not differentiate between soccer balls and the “distracters”. They also complained the game was too fast. As vision and reaction time are not products hip function, Soccer Heading and Penguin Slide should not be used. Super Hula-Hoop shows great promise as a prognostic exercise given the significantly higher Session 1 scores of the control group. Similar to the WOMAC survey, Super Hula-Hoop differentiates participants with hip pathology from those without. This difference is lost once the pathology is corrected. With further investigations, a cutoff point similar to that in Yamada et al. (2011) might be derived [10]. Our preliminary data suggests the cutoff for Super Hula-Hoop might lie between 33 and 48 points. Limitations include the small sample size, the randomized assessment of WFA2, and loss-to-follow-up in the THA group. It should be noted that most participants withdrew because of scheduling and transportation issues. This emphasizes the importance of local assessment convenient for THA patients.

Anecdotal comments about the use of the Wii Fit™ Plus system in this population include enjoyment using the system and communicated interest in self-purchasing a console for home use. Participant enjoyment was noted in other studies [7,13,19,20]. Although, a different study by Laver et al. (2011) found their population of hospitalized older adults to prefer conventional physiotherapy over Wii Fit [21]. In our study, there was some difficulty completing the 45-minute session due to fatigue.

In conclusion, this pilot study does not currently support the use of WFA1 or any of the undertaken exercises as measures of hip function. However, WFA1 and Super Hula-Hoop show potential in delineating hip function. Further evaluation with a larger cohort is required. Recommendations for continuation include scheduling study group follow-up sessions before 9-weeks post-operation, and eliminating WFA2, Penguin Slide and Soccer Heading. This would greatly reduce the duration of the assessment, reducing participant fatigue and increasing its feasibility for clinic implementation.

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