



## Exergaming Plus Conventional Treatment on the Functionality of a Patient with Anterior Cruciate Ligament Reconstruction - Case Report

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### Abstract

**Introduction:** Balance training has been used for patients who had undergone Anterior Cruciate Ligament (ACL) reconstruction. Exergaming allows the user to interact directly with the multidimensional environment and has been used to provide a realistic environment in physiotherapy settings. Thus, this study aimed to describe the effects of the combination of exergaming and conventional physiotherapy on the functionality after ACL reconstruction.

**Material and Methods:** A 43-years-old male was referred to a rehabilitation program due to an ACL reconstruction. A combination of exergaming and conventional physiotherapy was conducted for twenty weeks. Outcome measures included the International Knee Documentation Committee (IKDC), Cincinnati Knee Score, 10-Metre Walk Test (10 MWT), vertical jump test, Single-Leg Hop Test (SLHT), and Single-Leg Triple Hop Test (SLTHT). Data were collected at four-time points: week 10 after surgery, week 20 after surgery, week 30 after surgery, week 40 after surgery (follow-up).

**Results:** There was improvement in IKDC, week 10= 43.68 and week 40= 85.05; Cincinnati Knee Score, week 10= 63 and week 40= 80). Functional tests also showed higher values at the end of treatment: 10 MWT (week 10= 1.52 m/s and week 40= 3.55 m/s), jump test (week 10= 117 cm and week 40= 180 cm), SLHT (week 20= 387 cm and week 40= 526 cm) and SLTHT (week 20= 387 cm and week 40= 526 cm).

**Conclusion:** Adding exergaming to conventional physiotherapy may be beneficial to achieve functional improvements after ACL reconstruction.

**Keywords:** Anterior cruciate ligament; Rehabilitation; Virtual reality; Knee

### Introduction

The rehabilitation of the Anterior Cruciate Ligament (ACL) injury is a prevailing condition on the routine of knee treatment. An ACL injury is a common sports injury and also occurs during recreational physical activities [1]. The ACL contributes to knee joint stability and neuromuscular control [2]. ACL rupture may limit functional movements that involve cutting, jumping, and pivoting [3]. Also, collateral medial ligament rupture and meniscal tears frequently occur in association with ACL ruptures [4]. Surgical reconstruction is recommended after ACL rupture for elite athletes and for those whose knee instability persists after conservative treatment [4]. The rehabilitation should be initiated soon after surgical reconstruction [5].

The rehabilitation process after ACL reconstruction is divided into different stages. The initial procedures aim to control edema, muscles strengthening, restore the range of motion, and enhance functional movements [6]. The last phase of rehabilitation is based on the gesture performed in real-life sports [7], and balance training [6]. Individuals with ACL rupture usually present balance deficits after ACL reconstruction, and balance training needs to be included during the rehabilitation period [8]. Several resources are used for balance training, such as exercises on the ground, on unstable surfaces, and exercises with visual biofeedback through exergaming devices [5,9]. Exergaming is one exercise modality that allows the user to interact directly with a simulated environment through a television screen [10]. The multidimensional interaction with the environment, multi-

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sensory experience through visual, audio, and haptic sensations, increasing attention, motivation and adherence are advantages of the exergaming [10]. There are also increased body awareness, motor coordination, postural balance, and strength [11].

Studies reported positively on the use of modern technology *via* computer, video games, and virtual reality in the rehabilitation of patients with neurological diseases and balance disorders [12,13]. Nonetheless, it is still a growing prospect on the application in the orthopedic field [10,14]. Exergaming using Nintendo Wii<sup>®</sup> has been used to provide a realistic environment in physiotherapy settings [15]. However, only two studies have reported the use of Nintendo Wii<sup>®</sup> in the ACL post-operative rehabilitation [15,16]. Further, no study evaluated the effects of virtual reality on the hop tests. Therefore, it is necessary to report the functional outcomes of patients who had undergone ACL reconstruction, using conventional physiotherapy and exergaming in an associated program. The intervention used in the current case report can be a potential therapeutic strategy in future studies. Thus, this study aimed to describe the effects of the combination of exergaming and conventional physiotherapy on the functionality of a patient with ACL reconstruction.

## Material and Methods

A 43-years-old male patient, an employee of the xxx, recreational athlete, sought medical treatment on June 12<sup>th</sup>, 2009, after a traumatic sprained right knee in football, with clinical symptoms compatible with ACL rupture. Imaging exam showed complete ACL rupture, a grade I rupture of the medial collateral ligament and medial meniscus tear. ACL reconstruction surgery was performed with double gracilis and semitendinosus flexor tendon graft and partial meniscectomy in the xxx on May 25<sup>th</sup>, 2010. The participant signed a written informed consent before the inclusion. The study was approved by the Human Research Ethics Committee of xxx and performed in compliance with the Helsinki Declaration for research in humans.

The outcome measures included subjective assessment of the knee and objective measures of the lower extremity. The subjective assessments were performed by two self-reported instruments (International Knee Documentation Committee Subjective Knee Evaluation Form -IKDC, and The Cincinnati Knee Score). The objective assessments included the maximum walking speed during the 10-metre walk test, the vertical jump test, the single-leg hop test, and the single-leg triple hop test. Data were collected at four time points: baseline (week 10 after surgery), during the treatment (week 20 after surgery), end of treatment (week 30 after surgery), and

follow-up (week 40 after surgery). The single-leg triple hop test was not assessed on week 10 because the patient was afraid to perform the test.

A physiotherapist with three years of clinical experience in the musculoskeletal rehabilitation xxx performed the intervention from July to December 2010. Each session lasted approximately 45 min, and the intervention was performed twice weekly. All sessions occurred in the physiotherapy outpatient clinic at xxx. The intervention included two phases: Conventional physiotherapy and exergaming using the Nintendo Wii. Each phase of the physiotherapy program was performed in 10 weeks. Conventional physiotherapy included electrotherapy (i.e., functional electrical stimulation for muscle strength), myofascial technique, knee joint mobilization, stretching, and therapeutic exercises with weight and elastic bands. Subsequently, exergaming using Wii-rehab included lower limb strengthening and balance exercises through the Wii Fit Plus game. A detailed description of the Wii-rehab exercises is provided in Supplementary Table 1 and Supplementary Figure 1A-1H.

Aerobic exercise in a stationary bike was added on week 12, and strength training started on week 14. During this phase, additional devices such as ankle weights, balance boards, and mini trampoline were added in some exercises. The Wii Fit Plus exercises were similar to those routinely used for ACL injury rehabilitation [17]. There were no adverse events during the study. Descriptive statistical analysis of the data was performed in Prism software version 7.0 (GraphPad Software, Inc., CA, and USA).

## Results

The subjective assessment demonstrated an improvement in both instruments. The IKDC scores increased from 43.68 (week 10) to 85.05 (week 40) out of 100 points, and the Cincinnati Scale scores from 63 (week 10) to 80 (week 40) out of 100 points (Figure 1).

The objective assessment showed increased maximum walking speed for the 10-metre walk test: 1.52 m/s (week 10), 2.67 m/s (week 20), and 4.84 m/s (week 30). Despite that, the follow-up assessment presented lower walking speed (week 40= 3.55 m/s). Besides, the vertical jump test demonstrated improvements [week 10 (1.17 m), week 20 (1.36 m), week 30 (1.59 m), week 40 (1.80 m)] (Figure 2).

Single-leg hop test and single-leg triple hop test distance presented an improvement during the treatment, which persisted at follow-up evaluation for the injured side. The tests scores related to uninvolved healthy side values remained higher than the involved side in the

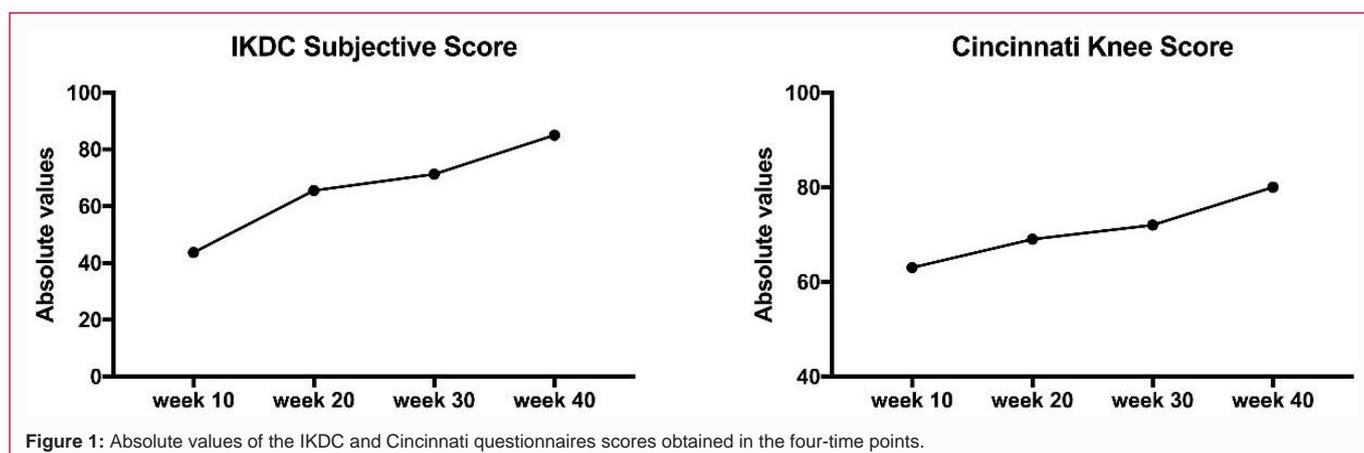
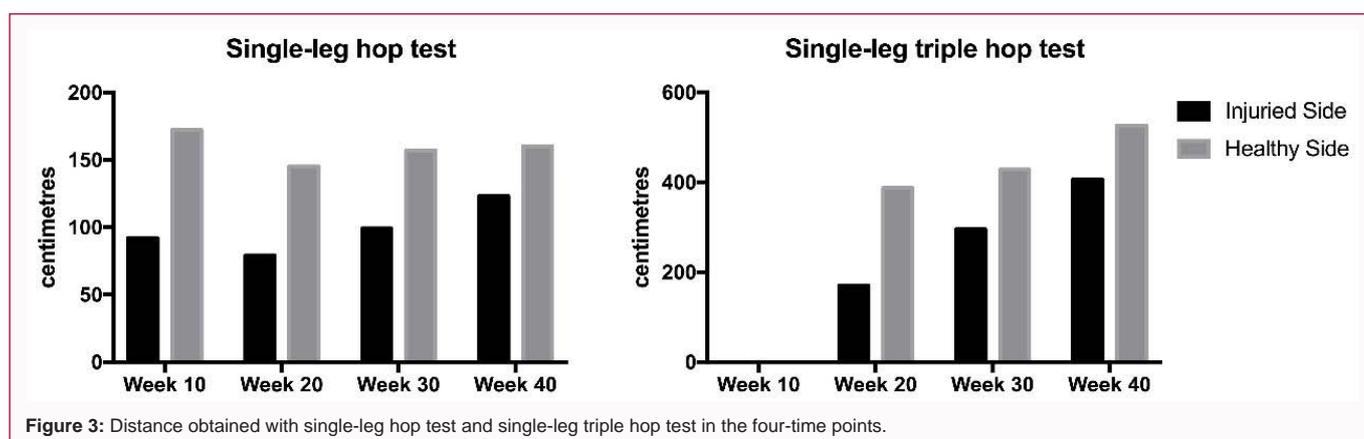
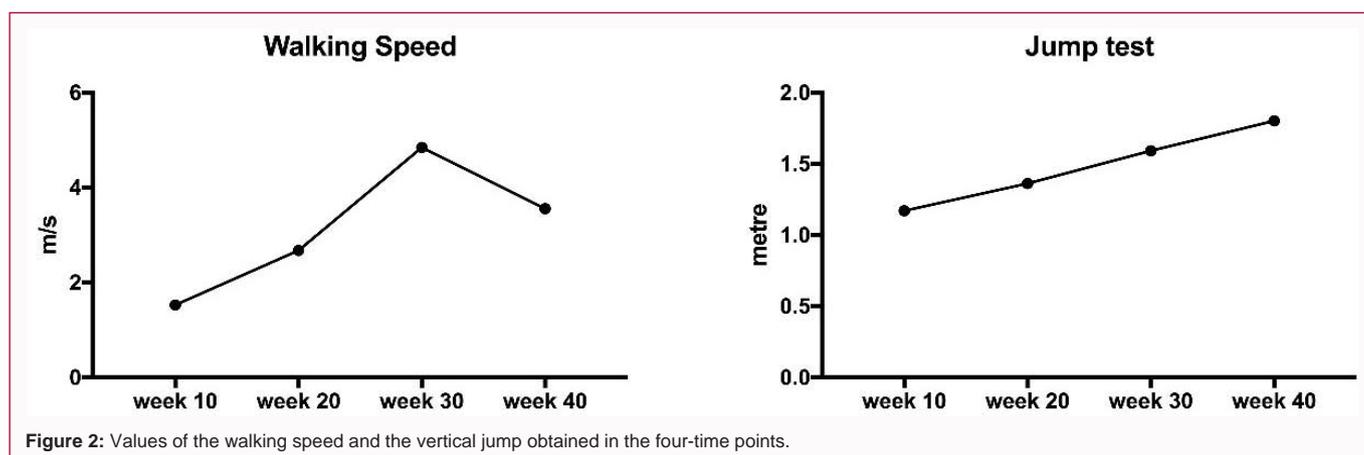


Figure 1: Absolute values of the IKDC and Cincinnati questionnaires scores obtained in the four-time points.



single-leg hop test (week 10= 172 cm; week 20= 145 cm; week 30= 157 cm; week 40= 160 cm) and single-leg triple hop test (week 10= not performed; week 20= 387 cm; week 30= 428 cm; week 40= 526 cm) (Figure 3). The highest leg symmetry of the hop tests was 77%, measured by the lower leg symmetry (involved side performance/uninvolved performance  $\times$  100%).

## Discussion

This study aimed to describe the effects of adding exergaming to a conventional rehabilitation program. The combination of the exergaming and conventional physiotherapy presented subjective and objective improvement after the rehabilitation period. The subjective measures demonstrated progressive improvement. The walking speed increased up to the end of treatment and reduced at the follow-up evaluation. The hop tests evidenced continuous improvement, and the single-leg hop tests showed a trend to reach similar results compared to the healthy side. Although the combination of the exergaming and the conservative treatment achieved satisfactory results, the case reported did not reach the recommended value for the limb symmetry (90%) in the hop tests [18].

There are few studies on Wii-rehabilitation in traumatology and orthopedic physiotherapy [7,8,15,16]. A previous study presented no difference between exergaming using Nintendo Wii and conventional treatment on functional tests [16]. The two approaches had similar improvement in patients after ACL reconstruction. Moreover, a protocol combining Nintendo Wii and conventional physiotherapy found similar findings related to knee range of motion in patients after ACL reconstruction and total knee arthroplasty surgery compared to

conventional physiotherapy [15].

Our case presented satisfactory results in the subjective assessment. For instance, the IKDC score was 85 out of 100 at week 40, which is similar to the mean of IKDC score (88.4) among subjects who returned to the sport after the ACL rehabilitation program [19]. The IKDC and the Cincinnati Knee Score are considered essential tools to evaluate knee function during the rehabilitation program [20,21]. Exergaming may play a role as an alternative approach for knee rehabilitation [10]. The Wii-rehabilitation could favor patient adherence to sessions due to the playfulness of the games [7,10].

Our findings demonstrated that the patient still improved in the functional tests, which can be associated with the restoration of the normal activities of daily living. Functional tests have been used in clinical settings to evaluate lower extremities performance and predict a return to sport [22]. Wii-rehabilitation could be used as an alternative tool for physiotherapists. The program may contribute to physical improvements as well as a conventional rehabilitation program [16]. We encourage further research with a larger sample size to provide new therapeutic strategies involving exergaming in musculoskeletal rehabilitation. In the current study, we offered treatment for an extended period, which probably contributed to functional advances observed on objective and subjective assessments. An exergaming rehabilitation program is feasible, safe, and cheap [11]. Thus, the exergaming may be used to improve functional tasks as squat, single-leg weight-bearing, and balancing training. The functional outcome of patients suggests that adding exergaming in rehabilitation can be a beneficial adjuvant for patients undergoing surgery for ACL reconstruction and partial meniscectomy. The case reported in the

current study was a 43-years-old male, non-professional athlete, and these characteristics may limit the use of the rehabilitation protocol in different populations. ACL injury is usually related to younger adults and athletes. Furthermore, the improvement observed in the functional test was low (limb symmetry <90%) despite the tendency to increase at follow-up and may be affected by the number of sessions per week. Future studies should compare groups with a different frequency of sessions to clarify this issue.

## Conclusion

The patient functional outcomes suggest that adding exergaming in rehabilitation can be a beneficial adjuvant for patients undergoing surgery for ACL reconstruction and partial meniscectomy.

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## Author's Contribution

MAMB: Conceptualization; Data curation; Formal Analysis; Investigation; Methodology; Project administration; Resources; Visualization; Writing - original draft; Writing - review & editing.

LAC: Data curation; Formal Analysis; Funding Acquisition; Investigation; Project administration; Resources; Visualization; Writing - original draft; Writing - review & editing.

GFT: Data curation; Formal Analysis; Funding Acquisition; Investigation; Project administration; Resources; Visualization; Writing - original draft; Writing - review & editing.

LACN: Conceptualization; Formal Analysis; Methodology; Project administration; Resources; Supervision; Visualization; Writing - original draft; Writing - review & editing.

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