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Article

Application of wearables to improve uptake of exercise therapy during hemodialysis treatment for reducing depression symptom – A single blinded randomized controlled trial

He Zhou [1], Fadwa Al-Ali [2], ; Gu Eon Kang [1], Abdullah Hamad [2], Rania Ibrahim [2], Talal Talal [3] and Bijan Najafi [1,]*

[1] Interdisciplinary Consortium on Advanced Motion Performance (iCAMP), Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, TX 77030, USA; he.zhou2@bcm.edu (H.Z.); hrahemi@gmail.com (H.R.); nishat.kulkarni@bcm.edu (N.K); bijan.najafi@bcm.edu (B.N.)
[2] Department of Nephrology, Hamad General Hospital, Doha, Qatar; falali1@hamad.qa (F.A.); ahamad9@hamad.qa (A.H.); ribrahim4@hamad.qa (R.I.)
[3] Diabetic Foot and Wound Clinic, Hamad Medical Co, Doha, Qatar; ttalal@hamad.qa (T.T.)
* Correspondence: najafi.bijan@gmail.com; Tel.: +1-713-798-7536

Abstract: Regular exercise can reduce depression. However, the uptake of exercise is limited in patients with end-stage renal disease undergoing hemodialysis. To address the gap, we designed a gamified non-weight-bearing exercise program (Exergame), which can be executed during hemodialysis treatment. The Exergame is virtually supervised based on its interactive feedback via wearable sensors attached on lower extremities. We examined the effectiveness of this program to reduce depression symptom compared to supervised exercise in 73 hemodialysis patients (age=64.5±8.7years, BMI=31.6±7.6kg/m^2). Participants were randomized into an Exergame group (EG) or a Supervised-exercise group (SG). Both groups received similar exercise tasks for 4-week, 3-session per week, 30-min per session, during hemodialysis treatment. Depression symptom was assessed at baseline and 4-week using Center for Epidemiologic Studies Depression (CES-D). Both groups showed significant reduction in depression score (37%, p<0.001, Cohen's effect size d=0.69 in EG vs. 41%, p<0.001, d=0.65 in SG) with no between-group difference for the observed effect (p>0.050). The EG expressed a positive exercise experience including fun, safety, and helpfulness of sensor-feedback. Together, results suggested that the virtually-supervised low-intensity Exergame is feasible during routine hemodialysis treatment. It is as effective as supervised-exercise to reduce depression symptom, while reducing burden of administrating exercise in dialysis clinics.

Keywords: Exergame; depression; hemodialysis; end-stage renal disease; wearable technology; digital health

1. Introduction

An estimated 2.62 million people worldwide rely on any form of renal replacement therapy, most commonly hemodialysis, to sustain their lives [1]. Depression, likely due to stressful and exhausting procedure as well as perceived feeling of deepening hopelessness and distress over the course of hemodialysis [2, 3], is the most common mental health problem among hemodialysis patients [4, 5]. Statistics show that depression has a prevalence of 20-40% among the hemodialysis population [5]. Depression in hemodialysis patients is an independent risk factor to increase the number of hospitalization, length of each hospitalization, and thus health care cost, and eventually mortality risk regardless of age, sex, and comorbid conditions [6, 7]. In addition, hemodialysis patients with depression have poorer physical and cognitive functions compared to those without depression [8, 9], resulting in lower quality of life [10]. Thus, there has been a growing clinical interest in treating depression in hemodialysis patients [11].

Although pharmacological treatment such as antidepressants is considered effective in treating depression in general population [12], its therapeutic efficacy in hemodialysis patients is not well established primarily due to patients' safety reasons [13]. There may be significant drug-to-drug interactions such as increasing risk of cardiovascular disorder, bleeding, and hypertension [14]. Instead, exercise therapy has been considered as an appropriate option to reduce depression in hemodialysis patients [15-19]. Scientists have demonstrated that release of beta-endorphin during exercise plays an important role in construction of hippocampal neurons and reduce depression [20]. In addition, exercise also reduces depression by changing the growth hormones and cortisol hormones [20].

However, due to the poor physical condition and medical complexity of the hemodialysis population, the approach and intensity of exercise should be carefully designed [21]. Conventional exercise strategies, including physiotherapy, aerobic exercise, and strength exercise, are not well suited for hemodialysis patients because even moderate exercise intensity can easily overtax them [21, 22]. In addition, there are three main factors limiting the adherence of exercise among hemodialysis patients: lack of time availability, post-dialysis fatigue, and limitation of transportation to exercise programs, which are usually offered in rehabilitation departments or cardiovascular centers but not in nephrology departments or regular dialysis clinics [23]. Because hemodialysis treatment often leaves patients feeling fatigued and thus, reluctant to engage in physical activity, any exercise outside of the dialysis clinic may not be practical. Therefore, although previous studies have demonstrated the effectiveness of using conventional exercise strategies to reduce depression symptom in hemodialysis patients, these studies suffer from small sample size (less than 15 participants) [15, 16, 18], low adherence rate (dropped out rate>30%) [15, 16], and adverse events during exercise [15].

Hemodialysis patients are required to visit dialysis clinics 3 time per week and spend 4 hours each time lying on a bed to receive the hemodialysis treatment. This facilitates a perfect opportunity to provide low-intensity non-weight-bearing exercise for this patient population. Several studies have demonstrated the feasibility and effectiveness of non-weight-bearing exercise programs during the hemodialysis treatment to reduce depression symptom [17, 19, 20]. In these studies, exercise trainers or nursing staffs were required to present during the whole exercise process to give instructions and guide the patient. However, in a real-world non-research situation, it is impractical to have an exercise trainer presenting in the dialysis clinic to guide each patient through the exercise. Having a nursing staff to administrate each exercise session for each hemodialysis patient is also impractical, which could easily overload an already overburdened dialysis clinic.

Recent advances in wearable technology have opened new opportunities to design virtually supervised exercise which can be applied anytime and anywhere [24-26]. To address the gaps described above, we have developed a low-intensity game-based non-weight-bearing lower extremities exercise program, we called Exergame, which can be performed during the hemodialysis treatment inside a regular dialysis clinic. The Exergame program can automatically guide the patient through the exercise process, which doesn't require the continuous attention of a nursing staff. In addition, by using wearable sensors and an interactive interface, the Exergame can provide gamification and visual-audio feedbacks during the exercise. This may add entertainment features into the exercise and potentially increase the exercise adherence. The primary aim of this study was to evaluate the feasibility, acceptability, and effectiveness of this novel Exergame program in reducing depression symptom among patients undergoing hemodialysis and compare to supervised exercise program with similar exercise tasks. We hypothesized that 1) the non-weight-bearing Exergame during hemodialysis treatment would be feasible and practical among hemodialysis patients; 2) the wearable sensor based Exergame would be as effective as supervised exercise program with similar exercise tasks administered by nursing staffs to reduce depression symptom in hemodialysis patients.

2. Materials and Methods

2.1. Study Population

This study is a secondary analysis of a clinical trial focused on examining the benefit of exercise in adult hemodialysis patients (ClinicalTrials.gov Identifier: NCT03076528). The clinical trial was offered to all eligible hemodialysis patients visited the Fahad Bin Jassim Kidney Center (Hamad Medical Corporation, Doha, Qatar) for hemodialysis treatment. To be eligible, the participant should be 50 years or older, be diagnosed with diabetes and end-stage renal disease that require hemodialysis, and have capacity to consent. Participants were excluded if they had major amputation; were non-ambulatory or had severe gait or balance problem (e.g., unable to walk a distance of 15-meter independently with or without assistive device or unable to stand still without moving feet); had active foot ulcer or active infection; had major foot deformity (e.g. Charcot neuroarthropathy); had changes in psychotropic or sleep medications in the past 6-week; with any antidepressant agents in the last 6-weeks; were in any active intervention (e.g. exercise intervention); had any clinically significant medical or psychiatric condition; or were unwilling to participate. All participants signed a written consent approved by the Institutional Review Board at the Hamad Medical Corporation in Doha, Qatar. All participants were randomly assigned into either an Exergame Group (EG) or a Supervised-exercise Group (SG). Participants were told that the purpose of this study is to examine benefits of a low-intensity exercise during hemodialysis treatment to improve function and quality of life. However, they were blinded to the group assignment. For the final data analysis, we only included those who had both valid baseline and 4-week data of Center for Epidemiologic Studies Depression (CES-D).

2.2. Exergame

The EG performed the proposed 4-week Exergame program under non-weight-bearing condition during their routine hemodialysis treatment, 3-session per week for 30-minute per session including breaks. Validated inertial sensors (LEGSys™, BioSensics, MA, USA) were used to estimate 3-dimensional joint angles needed for providing real-time feedback during the Exercise. The sensors were attached on the top of each foot of the participants in the EG using elastic straps (Figure 1A). The LEGSys sensor consists of a triaxial accelerometer (±2 g) and a triaxial gyroscope (±2000 deg/s). It can estimate foot motion such as inversion/eversion and dorsiflexion/plantarflexion [27-29]. Sensor data were acquired at the sampling rate of 100Hz, and transmitted to an interactive interface we designed and installed on a standard laptop. By rotating foot, the participant can navigate the laptop cursor for executing a simple reaching task game (Figure 1A). Participants were instructed to rotate their feet for navigating the cursor on the laptop-screen to target circles that appeared on the same screen. Exercise tasks started with simple point-to-point foot rotation in dorsiflexion and plantarflexion (navigating the cursor up and down). Later, more complex exercise tasks were provided, which required complex movement of foot, including eversion/inversion rotation with different angles as well as cognitively challenged exercise such as the instrumented trail-making task (iTMT) described in details elsewhere [30-32].

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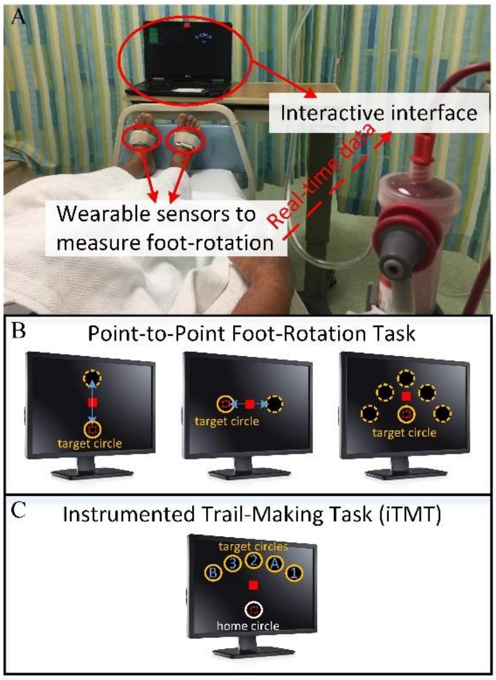

Figure 1. A) A patient performing the Exergame during hemodialysis treatment in a regular dialysis clinic; B) An illustration of the point-to-point foot-rotation task; C) An illustration of the instrumented trail-making task (iTMT).

The point-to-point foot rotation task was a motor task that requires accurate coordination of foot motion. For the point-to-point foot rotation task, only the cursor (red square) and one target (solid circle) presented on the screen each time (Figure 1B). After a visual start signal, participants were instructed to navigate the red cursor into the target circle by rotating the foot. If a participant successfully completed a task (i.e., moved and stopped the cursor within the center of the target circle), the target circle disappeared, followed by a new presentation of a new target circle at another location (the dash circle in Figure 1B). Then the participant repeated the task. The participant was expected to compete a task rapidly (<2-second). Upon completing a task in 2-second, participants were rewarded with visual (the circle exploded) and audio (positive sound) feedbacks. If a participant moves too slowly (>2-second), the participant would receive a visual feedback informing the incorrect execution of the task (i.e., the color of the target circle changed from yellow to green).

The iTMT is a cognitive-motor task that requires accurate coordination of foot motion while performing a cognitive task (i.e., working memory). For the iTMT, a total of six circles appeared on the screen: one home circle in white and five target circles in yellow (Figure 1C). The target circles were located in a fanwise position in front of the home circle. Each target circle was marked with a number or letter (“1”, “2”, “3”, “A”, or “B”) in a randomized order. The iTMT began with the cursor (red square) positioning in the home circle. Participants were instructed to navigate the cursor from the home circle to the center of a target circle in the alternative order of numbers and letters. Specifically, participants navigated the cursor from the home circle to the center of the first target circle that had number “1” inside. Next, participants navigated the cursor back to the home circle, and then to the second target circle that had alphabet “A” inside. Participants repeated these tasks in the order of “home”-“1”-“home”-“A”-“home”-“2”-“home”-“B”-“home”-“3”. If a participant navigates the cursor to a correct target circle, the target circle would turn red and explode with a positive rewarding sound. If the participant navigates the cursor to a wrong target circle, visual and audio feedbacks would be provided indicating the mistake. If a participant makes a mistake, the participant would be instructed to go back to the home circle and re-do the task until successful completion. If a participant makes three consecutive mistakes, a visual cue (a flashing target circle) would appear to inform the correct order.

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2.3. Supervised-exercise

Participants randomized into the SG were also receiving hemodialysis 3-session per week. During each hemodialysis session, a nursing staff instructed the participant in the SG to participate in a 30-minute non-weight-bearing foot-rotation exercise program (including breaks) without any technology. The nurse-supervised exercise program contained exercise tasks and intensity similar as the Exergame. However it didn't provide any game-feature or visual-audio feedback. Instead of the interactive interface, the nursing staff guided the participant throughout the exercise program. The nurse-supervised exercise program also lasted 4-week.

2.4. Demographics and Clinical Data

Participants' demographics and health information including age, sex, height, weight, body-mass-index (BMI), duration of hemodialysis, fall history, and number of prescription medicines was collected. All participants underwent clinical assessments, including the Short Falls Self-Efficacy Scale (FES-I) [33], the Vibration Perception Threshold test (VPT) [34], the Ankle Brachial Index test (ABI) [35], and the glycated hemoglobin test (HbA1c) [36]. A cutoff of FES-I score of 11 or greater was used to identify participants with high concern about falling [33]. Plantar numbness was evaluated by the VPT measured on three plantar regions of interest in each foot: great toe, 5th metatarsal, and heel. A participant was designated with Diabetic Peripheral Neuropathy (DPN) if the maximum VPT value reached 25 volts or greater [34]. The ABI was calculated as the ratio of the systolic blood pressure measured at the ankle to the systolic blood pressure measured at the upper arm. A participant was designated with Peripheral Artery Disease (PAD) if the measured ABI value was either greater than 1.2 or less than 0.8 [35].

2.5. Assessment of Depression Symptom

Depression symptom was assessed using the CES-D scale [37]. As suggested by previous literature, a cutoff score of 16 or greater in CES-D was used to identify participants at risk for clinical depression [37].

2.6. User Experience

We evaluated the user experience of the Exergame program using a revised technology acceptance model (TAM) suggested by Schwenk et al. [38] with some modifications relevant to the scope of this study. The revised TAM questionnaire consisted of eight items, designing to evaluate perceived ease of use, perceived safety, perceived benefit, and attitude toward the use of the program. Each item was rated using a 5-level Likert-scale (0=completely disagree; 1=disagree moderately; 2=neutral; 3=agree moderately; 4=absolutely agree).

2.7. Statistical Analysis

All continuous data were presented as mean ± standard deviation. All categorical data were expressed as count (percentage). Shapiro-Wilk test was applied for testing the normality of data. Between-group differences for continuous demographics and clinical data were compared using an independent t test. Between-group differences for categorical demographics and clinical data were compared using a Chi-square test. The effect of exercise on depression symptom was evaluated using repeated measures comparing the groups' CES-D scores between pre- (i.e., baseline) and post-exercise (i.e., 4-week). The effect size to discriminate between pre- and post-exercise was estimated using Cohen's *d* effect size [39]. The correlation between baseline CES-D score and reduction in CES-D score from pre- to post-exercise was evaluated using Pearson's correlation. The correlation coefficient was also interpret as effect size [39, 40]. A two-sided $p<0.050$ was considered to be statistically significant. All statistical analyses were performed using IBM SPSS Statistics 25 (IBM, IL, USA).

3. Results

Eighty-one participants satisfied the inclusion and exclusion criteria of this study. However, the CES-D data was available and valid for only 73 participants at both baseline and 4-week. The analysis of demographics and clinical data for the remaining participants was summarized in Table 1. After the randomization, 37 participants were assigned into the EG, and 36 were assigned into the SG. Between the EG and SG, no difference was observed for age, sex, height, weight, BMI, duration of hemodialysis, fall history, number of prescription medications, plantar sensation, prevalence of DPN, prevalence of PAD, or HbA1c value (all $p>0.050$).

Table 1. Demographics and clinical data of the study population.

	Exergame group (EG, n=37)	Supervised-exercise group (SG, n=36)	*p*-value
Demographics			
Age, years	62.7 ± 6.8	66.5 ± 10.0	0.060
Sex (female)	18 (49%)	22 (61%)	0.285
Height, m	157.1 ± 25.4	157.5 ± 10.2	0.932
Weight, kg	77.8 ± 17.2	82.4 ± 22.9	0.328
BMI, kg/m^2	30.0 ± 6.3	33.2 ± 8.4	0.068
Clinical data			
At risk for clinical depression (CES-D≥16)	11 (30%)	16 (44%)	0.193
Duration of hemodialysis, years	4.8 ± 5.0	4.0 ± 3.8	0.487
Had fall in last 12-month	8 (22%)	9 (25%)	0.733
FES-I, score	12.7 ± 5.2	14.7 ± 6.3	0.134
High concern about falling (FES-I≥11)	19 (51%)	24 (67%)	0.184
Number of prescription medications, n	8 ± 3	7 ± 3	0.835
Plantar sensation (VPT), V	33.2 ± 17.1	33.7 ± 15.9	0.885
Diabetic Peripheral Neuropathy (VPT≥25)	22 (60%)	23 (64%)	0.697
Peripheral Artery Disease (ABI<0.8 or ABI>1.2)	20 (54%)	25 (69%)	0.176
HbA1c, %	6.6 ± 1.6	6.9 ± 1.6	0.378

BMI: body-mass-index; CES-D: Center for Epidemiological Studies Depression; FES-I: Short Fall Efficacy Scale-International; VPT: Vibration Perception Threshold; ABI: Ankle Brachial Index

All participants in the EG and SG completed all exercise sessions of the 4-week program. No adverse event related to the Exergame or foot-rotation exercise was reported. Table 2 showed the descriptive results of the user experience TAM questionnaire in mean, standard deviation, median, and range. The majority of the EG participants "absolutely agreed" (i.e., rated 4 out of 4 in the Likert-scale) in having fun while exercising (mean score=3.22) and experiencing no problems or safety concerns (mean score=3.56). The sensor-feedback helped the majority of the EG participants learn the exercises quickly (mean score=3.67). The majority of the EG participants agreed that the form and design of the technology was optimal (mean score=3.50). Most participants disagreed that exercises were too fast or exhausting (mean score=0.25). Participants disagreed moderately that movements were difficult to perform (mean score=0.86).

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Table 2. Results of the user experience questionnaire.

Question	Mean	Standard Deviation	Median	Range
1: It was fun to use the sensor based exercise technology	3.22	0.19	4	0-4
2: Usage of the technology was possible without problems at any time	3.56	0.13	4	1-4
3: The form and design of the technology are optimal for me	3.50	0.13	4	2-4
4: I feel more energetic at home after doing exercise	3.03	0.20	4	1-4
5: Thanks to the sensor-feedback, I could quickly learn all exercises	3.67	0.10	4	2-4
6: I feel that the exercises were going too fast and exhausting me	0.25	0.12	0	0-3
7: Some of the movements were difficult to perform	0.86	0.19	0	0-3
8: I felt safe using the exercise technology	3.75	0.07	4	3-4
Answer categories: 0=disagree completely; 1=disagree moderately; 2=neutral; 3=agree moderately; 4=agree absolutely				

At the baseline of the exercise program, 27 participants (37%) were identified at risk for clinical depression (CES-D≥16) in the two groups. At the end of the exercise program, the number of participants at risk for clinical depression in the EG reduced by approximately 36% (n=11 for pre-exercise; n=7 for post-exercise), and the number of participants at risk for clinical depression in the SG reduced by approximately 43% (n=16 for pre-exercise; n=9 for post-exercise). Figure 2 illustrated changes in the CES-D score between the pre- and post-exercise for both groups. After 4-weeks of exercise, compared to baseline, the CES-D score reduced from 12.9±6.0 to 8.1±7.8 in the EG (37% reduction, $p<0.001$, $d=0.69$), and from 16.8±11.0 to 9.9±10.5 in the SG (41% reduction, $p<0.001$, $d=0.65$). There was no significant difference in reduction of CES-D score between the EG and SG ($p=0.246$).

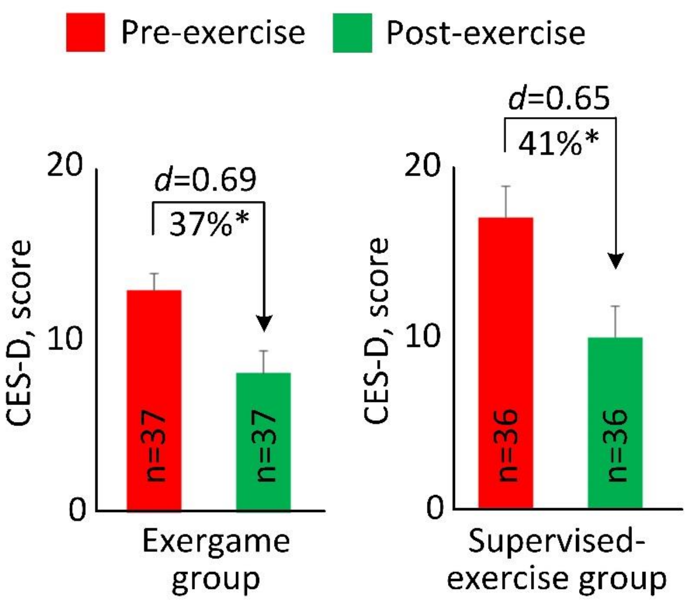

Figure 2. Pre- and post-exercise CES-D score for the Exergame group and the Supervised-exercise group. Error bar represents the standard error. "n" denotes number of participants per group. "*d*" denotes Cohen's *d* effect size. "*" denotes when the between-group comparison achieved a statistically significant level ($p<0.050$).

Figure 3 demonstrated the correlation between the baseline CES-D score and the score reduction for both the EG and the SG. A significant correlation with medium effect size was observed, indicating that participants with higher CES-D score at baseline had more reduction in CES-D score at 4-week ($r=0.432$, $p<0.001$).

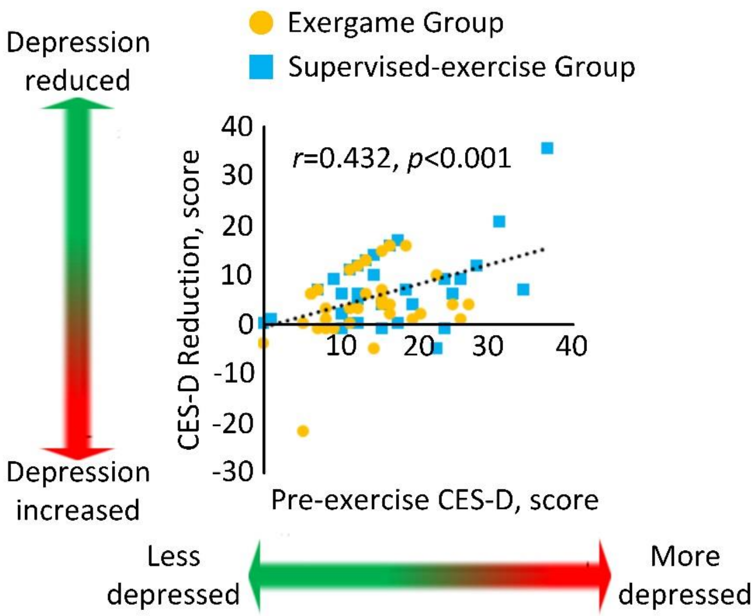

Figure 3. Correlation between the baseline CES-D score and the score reduction for the Exergame and Supervised-exercise groups.

4. Discussion

To our knowledge, this is the first study that used wearable technology to provide a game-based non-weight-bearing exercise program for hemodialysis patients. We were able to confirm our hypothesis that the proposed exercise program is feasible and practical to be performed during routine hemodialysis treatment inside a regular dialysis clinic. It is acceptable among patients undergoing hemodialysis. In addition, this is the first study that objectively evaluated the effect of the low-intensity non-weight-bearing Exergame to reduce depression symptom in hemodialysis patients. We have demonstrated that the virtually supervised exercise therapy is as effective as supervised exercise therapy to reduce depression symptom. No requirement for continuous attention of a physical therapist or a trained nursing staff for the Exergame program is however considered as an advance compared to supervised exercise intervention. This may improve the uptake of routine exercise intervention for hemodialysis patients, without adding significant burden to the already overburdened nursing staffs in dialysis clinics.

Comparing to the conventional exercise strategies, the advantage of the low-intensity non-weight bearing exercise program is that it can be performed while patients receiving routine hemodialysis treatments in regular dialysis clinics. In order to participate in the conventional physical exercise, hemodialysis patients usually need to visit an out-clinic facility on a non-dialysis day [41], which greatly limits the adherence of exercise. Moreover, for patients with severe physical and physiological issues, it is even more difficult to bring them to an out-clinic facility on a non-dialysis day for exercise [23]. In addition, due to the deconditioning in physical function [42], the conventional exercises such as cycling, walking, jogging, and resistance training may become too difficult for hemodialysis patients and easily overtax them [21, 22]. On the other hand, the Exergame enables adjustable exercise tasks depending on the motor capacity and cognitive status of the patient. In this study, most participants agreed that the Exergame were not too fast nor exhausting. They didn't experience any problem or safety concern. No adverse event related to the Exergame occurred.

Previous studies have demonstrated effects of non-weight-bearing exercise, such as ankle rotation, toe flexion & extension, joint warming action, stretching exercise, etc., during hemodialysis treatment to reduce depression symptom. Razaei et al. provided a 35-minute non-weight-bearing exercise program 3-time per week for 10-week to 25 hemodialysis patients. At the end of the program, the depression score significantly decreased by 53% (p<0.001) [19]. Samson et al. recruited 7 hemodialysis patients and provided them a 15-minute non-weight-bearing exercise program during

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hemodialysis treatment for 8-week [20]. Trends of reduction in depression, anxiety, and stress (Chi square = 0.295-1.333) were observed at the end of the exercise program [20]. In our present study, results demonstrated that our Exergame program is also efficient to reduce depression symptom in hemodialysis patients, even with a shorter period of time (4-week). In addition, our results showed that hemodialysis patients with more severe depression symptom (higher CES-D score) enjoyed more benefits from the Exergame program.

In this study, the SG also received 4-week (3-session per week, 30-minute per session) non-weight-bearing foot-rotation exercise without any technology, game-feature, or visual-audio feedback, but under a supervision by nursing staffs. Comparing to the nurse-supervised exercise, wearable and interactive interface technologies enable real-time visual and audio feedbacks in the Exergame. Hemodialysis patients can visually perceive their performances and errors during the exercise. In the Exergame, hemodialysis patients need to rotate ankle joint to certain range and achieve certain speed to complete the exercise task. This can standardize the exercise intensity and push the boundary of hemodialysis patients. The Exergame also includes game-features such as rewarding elements and animations, which could be more attractive than the non-technological foot-rotation exercise. Therefore, it has the potential to increase exercise adherence and be more efficient to reduce depression symptom [43]. Furthermore, the Exergame is virtually supervised by the computer program. It can reduce the burden of administrating exercise during hemodialysis treatment, making the exercise more feasible and practical in a regular dialysis clinic. It also has the potential to facilitate tele-rehabilitation.

A major limitation of this study is the relatively low sample size, which could be underpowered for the clinical conclusion. This study is a secondary analysis of a clinical trial focused on examining the benefit of Exergame in gait and balance among hemodialysis patients. We only performed CES-D for depression assessment in the clinical trial. The CES-D is a screening test for depression symptom but not a sufficient tool to diagnose depression. A future study using comprehensive psychological assessments for evaluating depression is needed. Due to the same reason, we did not have a non-exercise control group in this study. However, the effectiveness of low-intensity non-weight-bearing exercise during hemodialysis treatment to reduce depression symptom has been demonstrated in previous studies [17, 19, 20]. In this study, we aimed to provide a sensor based Exergame with gamifications and real-time visual-audio feedbacks, which may increase the exercise adherence and relieve the burden of administrating exercise during routine hemodialysis treatment. In this study, although randomization was done using a computer-generated list, the EG and SG were not perfectly randomized. The EG had lower prevalence of risk for clinical depression and lower average CES-D score than the SG at the baseline. However, the difference didn't reach statistical significance. So we didn't adjust the results by pre-exercise depression score. In this study, we evaluated the immediate reduction of depression score after 4-week of the Exergame program. However, the ideal dosing of intervention and retention of exercise benefit remain unclear. These limitations should be addressed in future studies.

5. Conclusions

This study demonstrated the feasibility and acceptability of the sensor based non-weight-bearing Exergame program to be performed during routine hemodialysis treatment in a regular dialysis clinic. The sensor based Exergame program enables delivering a personalized and virtually supervised exercise intervention, with similar effect as supervised exercise therapy, to reduce depression symptom in hemodialysis patients, especially in those with severe depression symptom. Its key advantage compared to supervised exercise is no requirement for continuous attention of a physical therapist or a trained nursing staff. It can reduce the burden of implementing exercise intervention during routine hemodialysis treatment.

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Conflicts of Interest: None.

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