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Effects of Kinect-Based Mixed Reality Device on Physical Function and Quality of Life in Breast Cancer Survivors : A randomized controlled trial

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Abstract

Purpose : We aimed to evaluate the impact of a exercise with kinect-based mixed reality device (KMR) on physical function, upper extremity disability, fatigue, and quality of life in breast cancer survivors. We hypothesized that this exercise program would improve physical function, physical activity, fatigue, and quality of life.

Methods : Thirty-nine breast cancer survivors were randomized to either the KMR exercise group (KE) or the home stretch group (HS). The KE participated in 8 weeks of exercise, exercising 3 times per week, while the HS performed 8 weeks of stretching exercises, also 3 times per week. Before and after the intervention period, participants underwent assessments of physical function, including body composition, chester step test (CST), and hand grip strength (HGS). Additionally, participants completed questionnaires including the international physical activity questionnaire (IPAQ), disabilities of the arm, shoulder and hand (DASH) questionnaire, and functional assessment of cancer therapy-breast (FACT-B) questionnaire to measure their physical activity levels, upper extremity disability, and quality of life, respectively.

Results : Overall, significant improvements were observed in several shoulder movements, body weight, and physical activity, with no significant interaction effects between groups and time. Furthermore, there was a significant group by time interaction for body weight, left flexion, right flexion, right abduction, and left adduction, as well as for upper extremity disability (K-DASH) and quality of life (FACT-B).

Conclusion : In conclusion, the KMR exercise program was found to be effective at improving physical function, upper extremity disability, quality of life, and overall well-being in breast cancer survivors. The significant improvements observed in multiple measures and the significant group by time interactions for various outcomes highlight the potential benefits of this KMR exercise program in promoting a better quality of life for breast cancer survivors.

Key Words : breast cancer, cancer survivor, exercise, kinect-based mixed reality, virtual reality

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Ⅰ. Introduction

Breast cancer became the leading cause of global cancer incidence in 2020, surpassing lung cancer, with an estimated 2.3 million new cases representing 11 % of all cancer cases. Further, it is the fifth leading cause of cancer mortality worldwide, with 685,000 deaths (Sung et al., 2021). Changes in lifestyle, sociocultural, and built environments brought about by growing economies and an increase in the proportion of women in the industrial workforce have all had an impact on the prevalence of breast cancer risk factors.

In South Korea, breast cancer ranks as the sixth (8 %) cause of cancer among women death (Korea Central Cancer Registry, 2019). According to data from the Korea central cancer registry, there were 26,534 cases of breast cancer in Korea in 2017. With increasing survival rates due to early diagnosis and advanced treatment modalities, the number of breast cancer survivors is also rising. The 5-year relative survival rate of Korean breast cancer patients is 93 %, much higher than that of many other cancers. Among Korean cancer survivors, 217,000 are breast cancer survivors, ranking 4th (11 %) among all cancers (Kang et al., 2020).

Breast cancer survivors who maintain a healthy weight, regularly practice physical activity, abstain from drinking, and eat well-balanced foods have significantly lower mortality rates (Eakin et al., 2015). However, a study evaluating obesity among breast cancer survivors in Korea found that 67 % were overweight and 48 % were obese with low physical activity (Seo et al., 2014).

Exercise is an effective non-pharmacologic strategy to mitigate cancer-related treatment side effects and to improve quality of life, cardiorespiratory fitness, and muscular strength among breast cancer survivors (Speck et al., 2010; Stout et al., 2017). Several meta-analyses and randomized controlled trials have previously reported that exercise is associated with improvements in cardiorespiratory fitness; disabilities of the arm, shoulder, and hand (DASH); physical fitness and quality of life; as well as social function in breast cancer survivors (Boing et al., 2020; Speck et al., 2011).

Combining aerobic and resistance exercise may improve the quality of life (Dieli-Conwright et al., 2018a; Zhang et al., 2019) and attenuate adipose tissue inflammation in obese breast cancer survivors (Dieli-Conwright et al., 2018b). Breast cancer-related lymphedema is one of the most common side effects of cancer and its treatments (Baumann et al., 2018), and stretching, yoga, qigong, and pilates are safe and effective in the management of symptoms for those with or at risk of BCRL (Panchik et al., 2019). However, traditional exercise programs have

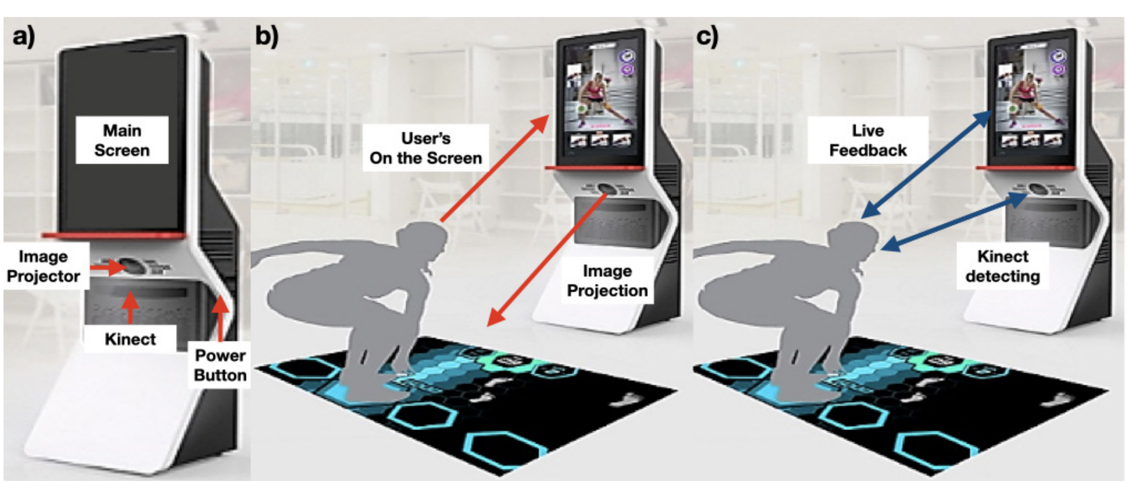

Fig 1. The KMR device records real-time data, subsequently providing feedback

limitations, including a lack of adherence and monitoring of exercise intensity and progression, as well as limited access to exercise facilities. These limitations can be addressed by utilizing a kinect-based mixed reality device (KMR), which offers several advantages over traditional exercise programs.

KMRs comprise three components: the kinect device, which tracks 25 body joints in real-time to recognize movements; the main screen, which displays the user's image; and the floor environment, which enables interaction between the user and augmented reality (Fig 1). KMRs store the user's movements as real-time data and provide feedback on posture through voice narration, inducing changes in posture. Changes in the user's movements can create a mixed reality environment by reflecting changes in augmented reality on the floor screen, allowing for interactive experiences (Ahn et al., 2022).

KMR based exercise programs can automatically save exercise data, allowing both patients and their healthcare providers to track progress and adjust exercise plans accordingly. The self-exercise feature of KMR based exercise programs further allows breast cancer survivors to perform exercise routines in the comfort of their preferred location, providing convenience and reducing barriers to exercise participation. The KMR can also provide real-time feedback to patients, allowing them to adjust their exercise intensity and progression.

The KMR used in this study has been validated in a previous study (Ahn et al., 2022), in which it was chosen as the exercise intervention tool for its ability to provide real-time feedback and facilitate enjoyable and engaging physical activity.

To the best of our knowledge, no study has yet been planned to investigate the efficacy of KMR with an exercise program for physical function, fatigue, upper extremity dysfunction, and QoL in breast cancer survivors. Acquiring more knowledge about how KMR based exercise programs influence health-related results will help healthcare workers offer better exercise guidance related to breast cancer survivors.

The aim of this study was to elucidate the effects of KMR based exercise programs on physical functioning as well as upper extremity disabilities and QoL in breast cancer survivors. We hypothesized that KMR based exercise program may effectively improve physical function, physical activity, fatigue, and QoL.

Ⅱ. Methods

1. Subjects

For this study, we enrolled 39 female breast cancer survivors. The inclusion criteria were as follows: patients who completed treatment at least 6 months prior, no history of metastatic diseases or other cancers, and absence of certain health conditions. The exclusion criteria included: severe cardiac disease, uncontrolled hypertension, and other health conditions.

The participants were randomly assigned to either the KMR based exercise group (KE) or the home Stretch group (HS). Randomization was conducted using a computer-generated sequence, and individual allocations were placed in sealed envelopes.

Ensuring the safety of participants was a primary focus in this study, and the exercise program was designed and implemented with great care to minimize the risk of adverse events or injury. Participants were instructed on how to recognize and report any adverse events or injuries. The program was also adjusted to a two-week duration and well-designed for safety, ensuring that the exercise intervention was both safe and effective for breast cancer survivors.

2. KMR (Kinect-based Mixed Reality device)

KMR is a device that utilizes motion capture technology to track body movements during exercise. It is a non-invasive and cost-effective tool which can help patients to improve their exercise performance and reduce the risk of injury.

KMR save the user's movements as real-time data, which can be used to provide feedback on exercise performance and help patients to adjust their exercise form and technique. The KMR device can also provide feedback on posture through voice narration, encouraging users to make changes and adjust their position as needed.

The interactive nature of KMR can also create a mixed reality environment by reflecting changes in augmented reality on the floor screen. This feature can help to create a more engaging and enjoyable exercise experience, which may encourage breast cancer survivors to adhere to their exercise program and achieve better health outcomes.

3. Procedures

The participants were divided into two groups, KE and HS (Fig 2). Prior to commencing the interventions, all participants underwent a pre-test that included assessments of hand grip strength (HGS), chester step test (CST), shoulder range of motion (ROM), as well as completion of questionnaires (K-DASH, K-IPAQ, FACT-B) and body composition analysis.

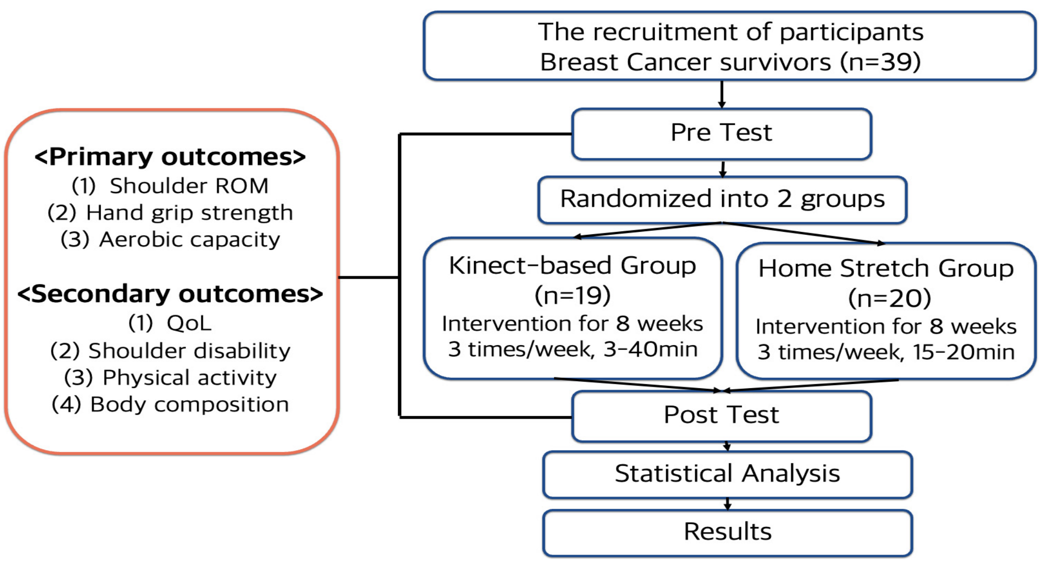

Fig 2. Experimental design

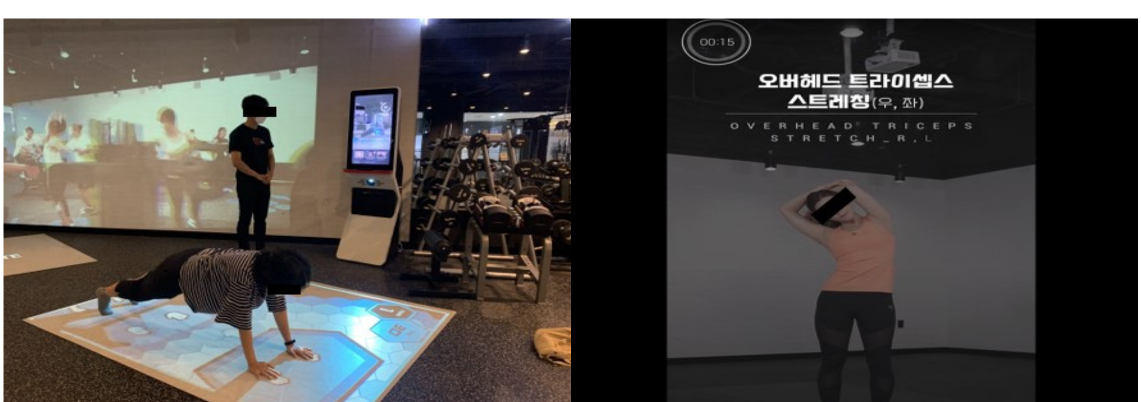

Fig 3. Overview of the actual interventions for the KE and HS groups

The KE group completed 8 weeks of exercise, with 3 unsupervised sessions per week lasting 30 minutes each.

Participants in the KE group began training within one week of completing the pre-tests. The exercise program was consistently conducted in a comfortable and safe environment with controlled temperature and humidity. During the first week of the intervention, participants were closely supervised by trained professionals to ensure proper execution of the KMR based exercise program. In contrast, participants in the HS were provided with videos containing general health recommendations for performing stretching exercises (Fig 3).

The intervention included a combination of cardiovascular, resistance, proprioception, and flexibility training, with a warm-up period of 5 minutes, a 20-minute main workout period, and a cool-down period of 5 minutes. Following the guidelines recommended by the American college of sports medicine, exercises were performed in 1-minute intervals, comprising 40 seconds of exercise and 20 seconds of rest.

The HS group performed 8 weeks of stretching exercises for 15 minutes, three times per week, in their preferred location. The stretching exercises were designed to be efficient and effective at removing lymphedema in breast cancer patients.

4. Outcome measures

1) Physical function

(1) Body composition

Body composition was measured using a multi-frequency bioelectrical impedance analysis platform (Inbody 720, InBody Co. Ltd, Korea). Both the body fat percentage and skeletal muscle mass were recorded. BMI was calculated by dividing the weight by height squared. Participants were instructed to abstain from exercise for the 8 hours before testing and consume only 12 oz of water 4 hours prior.

(2) Chester step test (CST)

Aerobic capacity was assessed using the CST, a validated submaximal exercise test commonly used in clinical and research settings to assess cardiorespiratory fitness in cancer patients (Jones et al., 2008; Sietsema et al., 2020). This test involves stepping up and down a 30 ㎝ step at a rate of 15 steps per minute, with the step height and duration of the test adjusted according to the participant's age and fitness level. The CST has been shown to have high reliability and validity in assessing cardiorespiratory fitness in various populations, including cancer patients, older adults, and healthy individuals (Ritchie et al., 2005; Sykes & Roberts, 2004).

(3) Hand grip strength (HGS)

The HGS test (TKK5401, Takei, Japan) was used in this study to assess upper extremity muscle strength (㎏) with a hand-held dynamometer. Subjects were instructed to apply maximal power for 3 seconds with the shoulder adducted and neutrally rotated, the elbow flexed at 180 °, and the forearm and wrist in a neutral position. An average of three attempts with each hand was used.

(4) Shoulder ROM

To measure shoulder ROM, participants were positioned either in a seated or standing posture, with their backs straight and feet planted firmly on the ground. Active flexion, extension, abduction, and adduction were assessed by instructing the participants to move their arms forward, backward, out to the side, and back down to their side, adopting the maximum range of motion they were comfortable with. During each movement, a digital goniometer (Easy Angle, Meloq, Sweden) was positioned on the participant's shoulder. Each measurement was repeated in triplicate to reduce error and improve reliability, and the average of the three measurements was recorded.

2) Questionnaires

(1) Korean version of the disabilities of arm, shoulder, and hand (K-DASH)

Shoulder disability was assessed using the K-DASH questionnaire, a validated tool widely used to measure functional status and symptoms associated with varying degrees of upper-extremity disability (Lee et al., 2008). The K-DASH questionnaire consists of 30 items, each with five possible responses, and is divided into three categories: 21 items assess the degree of difficulty in performing activities of daily living (DASH-ADL), six items assess symptoms (DASH-symptom), and the remaining three items assess the psychosocial impact (DASH-social). The DASH questionnaire is widely used and has been shown to be a reliable and valid tool for assessing shoulder disability in a variety of populations (Hudak et al., 1996; Jester et al., 2005).

(2) Functional assessment of cancer therapy-breast cancer (FACT-B)

Health-related quality of life (QOL) was assessed using the FACT-B. This 36-item questionnaire measures both general QOL associated with cancer (FACT-G), comprising 27 items, and breast cancer-related QOL, comprising an additional 9-item subscale called the breast cancer subscale (BCS). The FACT-G subscales include physical well-being (PWB), functional well-being (FWB), emotional well-being (EWB), and social/family well-being (SWB).

(3) International physical activity questionnaire (IPAQ)

The physical activity levels of participants were assessed using the IPAQ (Chun, 2012; Craig et al., 2003). Participants were asked to report the duration and frequency for which they engaged in moderate and vigorous physical activity during the previous 7 days.

The questionnaire consists of 7 items that use yes/no and fill-in-the-blank questions to assess the time spent per week engaged in various types and intensities of physical activity. Each activity and intensity score is given a metabolic equivalent (MET) value according to the published manual (e.g., walking =3.3 METs, moderate intensity=4.0 METs, vigorous intensity=8.0 METs) (Gary, 2021; Pate et al., 1995).

5. Statistical analysis

Statistical analysis was performed to assess the exercise-related effects of the intervention. A two-way ANOVA with repeated measures was conducted to analyze the data, with group and time set as the factors. Statistical analysis was performed using SPSS version 26.0 software. A p-value of less than .05 was considered statistically significant, and independent t-tests were conducted to determine the presence of a mean difference.

Ⅲ. Results

1. General characteristics of the study subjects

Overall, 39 breast cancer patients were enrolled in this study. The general characteristics of the subjects are shown in Table 1. No significant difference (p>.05) in descriptive and dependent variables was observed among the groups at baseline.

Table 1. General characteristics of the study participants (n=39)

Variables	Total (n=39)	KE (n=19)	HS (n=20)	t
	Mean±SD	Mean±SD	Mean±SD	
Age (years)	49.43±7.52	48.96±5.49	49.89±7.23	.88
Height (㎝)	15.83±5.79	159.70±6.11	157.96±5.31	.93
Body weight (㎏)	57.26±11.04	58.05±7.36	56.47±7.01	.85

KE; KMR based exercise group, HS; home stretch group, Mean±SD; mean±standard deviation

2. Physical function

The pre and post-test results for body composition, CST, HGS, and shoulder ROM are shown in Table 2.

Table 2. Changes in physical function from the pre to the post-test across the two groups (n=39)

Variables	Group	Pre-test Mean±SD	Post-test Mean±SD	Source	F	*p*
Body weight (kg)	KE (n=19)	57.34±12.55	56.60±12.41	G	.02	.893
				T	.21	.648
	HS (n=20)	57.20±9.73	57.71±9.80	G×T	6.18	.018
Flexion Left (°)	KE (n=19)	151.21±15.48	160.21±15.61	G	4.89	.033
				T	41.88	.000
	HS (n=20)	163.25±10.69	166.55±10.84	G×T	9.00	.005
Flexion Right (°)	KE (n=19)	151.79±15.83	160.63±15.24	G	3.49	.070
				T	16.40	.000
	HS (n=20)	164.45±14.57	165.25±14.01	G×T	11.41	.002
Extension Left (°)	KE (n=19)	50.37±10.95	51.68±9.50	G	.12	.735
				T	.90	.349
	HS (n=20)	49.80±9.61	50.30±7.44	G×T	.18	.672
Extension Right (°)	KE (n=19)	46.37±11.72	48.89±9.16	G	.04	.842
				T	4.17	.048
	HS (n=20)	48.30±9.63	49.15±8.52	G×T	1.56	.220
Abduction Left (°)	KE (n=19)	151.84±33.21	156.16±31.92	G	3.35	.075
				T	18.89	.000
	HS (n=20)	166.35±12.93	170.25±13.19	G×T	.05	.827
Abduction Right (°)	KE (n=19)	139.848±40.14	147.95±40.08	G	3.32	.077
				T	20.83	.000
	HS (n=20)	161.05±21.07	163.35±19.82	G×T	6.48	.015
Adduction Left (°)	KE (n=19)	51.53±11.19	46.95±11.87	G	.60	.445
				T	1.19	.281
	HS (n=20)	45.60±12.58	47.25±12.65	G×T	5.40	.026*
Adduction Right (°)	KE (n=19)	46.00±13.69	46.95±11.87	G	.12	.728
				T	.05	.821
	HS (n=20)	48.70±16.50	47.25±12.65	G×T	1.18	.284
HGS (kg)	KE (n=19)	19.37±3.40	20.29±3.38	G	1.96	.017
				T	5.20	.028
	HS (n=20)	18.31±2.80	18.69±2.83	G×T	.87	.358
VO_2max (㎖/kg/min)	KE (n=19)	36.20±5.66	36.88±6.27	G	2.93	.095
				T	.29	.767
	HS (n=20)	39.50±4.82	39.14±4.60	G×T	.87	.357

G; group, T; time, G×T; interaction, HGS; hand grip strength

We found no significant interaction effects between groups and time for left extension, right extension, left abduction, right adduction, HGS, or VO_2max. However, statistically significant effects over time were observed for left flexion ($p<.001$), right flexion ($p<.001$), right extension ($p<.05$), left abduction ($p<.001$), right abduction ($p<.001$), and HGS (p<.05). Furthermore, in the KE group, the right extension increased by 2.52 ° from 46.37±11.72 to 48.89±9.16 pre and post-test, the left abduction increased by 4.32 ° from 151.84±33.21 to 156.16±31.92 pre and post-test, and HG increased by .92 ° from 19.37±3.40 to 20.29±3.38 pre and post-test.

Repeated measures analyses of variance revealed a significant group by time interaction for body weight (p=.018), left flexion (p=.005), right flexion (p=.002), right abduction (p=.015), left adduction (p=.026).

3. Questionnaire

The pre and post-test measurement results for the K-DASH, IPAQ, and FACT-B are shown in Table 3.

We found no significant interaction effects between groups and time for FACT-B, however, statistically significant effects over time were observed between FACT-B (p<.01) and K-DASH (p<.001). In KE, the FACT-B increased by 3.52 from 61.74±10.55 to 65.26±11.64 pre and post-test. Furthermore, repeated measures analyses of variance revealed a significant group by time interaction for shoulder pain (p=.002) and physical activity (p=.009) (Table 3).

Ⅳ. Discussion

Breast cancer survivors often experience a decline in physical function and quality of life, in addition to increased levels of fatigue. Exercise interventions have been recommended as a means to alleviate these negative effects (Battaglini et al., 2014; Hayes et al., 2019; Mishra et al., 2014). In the present study, we aimed to evaluate the effectiveness of an 8-week kinect-based exercise program on various measures of physical function, quality of life, and fatigue in breast cancer survivors. Overall, our results demonstrated significant improvements in several measures of physical function, including shoulder movements, body weight, and upper extremity disability, as measured by the K-DASH questionnaire. These findings are consistent with prior research demonstrating the positive effects of exercise interventions for breast cancer survivors (Schmitz et al., 2010; Segal et al., 2003).

Comparing the results of these studies to the current study, our findings align with those of Schmitz et al. (2010) and Mishra et al. (2012), which found positive effects of exercise interventions on physical function and quality of life in breast cancer survivors. Schmitz et al. (2010) measured hand grip strength and quality of life, while Mishra et al. (2012) measured quality of life and cardiovascular fitness. However, our study also found

Table 3. Changes in questionnaire answers pre and post-test across the two groups (n=39)

Variables	Group	Pre-test Mean±SD	Post-test Mean±SD	Source	F	*p*
K-DASH	KE (n=19)	46.65±9.64	40.75±9.43	G	.02	.903
				T	20.47	.000
	HS (n=20)	43.94±10.52	43.21±9.28	G×T	11.24	.002
IPAQ	KE (n=19)	1163.47±652.87	1275.05±661.83	G	.03	.871
				T	3.47	.070
	HS (n=20)	1197.95±621.10	1176.00±541.94	G×T	7.70	.009
FACT-B	KE (n=19)	61.74±10.55	65.26±11.64	G	.23	.637
				T	652	.005
	HS (n=20)	61.45±9.80	62.50±8.99	G×T	2.65	.112

G; group, T; time, G×T; interaction, K-DASH; Korean version of the disabilities of arm, shoulder and Hand, IPAQ; international physical activity questionnaire, FACT-B; functional assessment of cancer therapy-breast cancer significant reductions in shoulder pain and fatigue, which were not consistently reported in these previous studies.

The differences in the findings between our study and these previous studies could be due to several factors, including differences in the type and duration of the exercise intervention, the population of breast cancer survivors included in the study, and the outcome measures used to assess physical function, quality of life, and fatigue.

It is noteworthy that the KMR based exercise program did not show significant interaction effects for left extension, right extension, left abduction, right adduction, HGS, or VO_2max. However, significant effects over time were observed for left flexion, right flexion, right extension, left abduction, right abduction, and HGS. This suggests that the program was effective at improving specific aspects of physical function in breast cancer survivors.

In terms of quality of life, our results showed statistically significant effects over time for FACT-B, indicating that the KMR based exercise program may have positive effects on the quality of life in breast cancer survivors. Although there were no significant interaction effects between groups and time for FACT-B, these findings align with prior research demonstrating that exercise interventions may improve the quality of life in breast cancer survivors(Courneya et al., 2003; McNeely et al., 2006). In addition, our repeated measures analyses of variance revealed a significant group by time interaction for body weight, left flexion, right flexion, right abduction, and left adduction. These findings indicate that the KMR based exercise program was more effective than the HS at improving these measures of physical function.

Furthermore, our analyses revealed a significant group-by-time interaction between shoulder pain and physical activity, indicating that the KMR based exercise program effectively reduced shoulder pain and increased physical activity in breast cancer survivors. These results are consistent with previous research suggesting that exercise can reduce pain and improve physical activity in breast cancer survivors (Pinto et al., 2005; Velthuis et al., 2010).

Although our results are promising, this study has a number of limitations that require caution in the interpretation of the results. One limitation is the small sample size, which may have limited the statistical power of our analyses. Another limitation is the relatively short duration of the intervention period, which precluded us from drawing conclusions regarding the long-term effects of the exercise program. Future randomised controlled trials of a larger size and with longer follow-up periods are needed to address these limitations.

Nevertheless, despite these limitations, our findings suggest that the KMR based exercise program could be an effective intervention for breast cancer survivors to enhance their physical function, quality of life, and overall well-being. The significant improvements observed in several measures of physical function and quality of life, as well as significant reductions in shoulder pain and fatigue, underscore the potential benefits of exercise interventions for breast cancer survivors. We hope our study will stimulate further research into exercise interventions for breast cancer survivors and encourage healthcare providers to incorporate exercise into the standard care for this expanding patient group.

Ⅴ. Conclusion

In conclusion, our study provides evidence that an 8-week KMR based exercise program can improve various aspects of physical function, quality of life, and fatigue in breast cancer survivors. Overall, we show that the KMR based exercise program could be a useful intervention for breast cancer survivors and suggest that further research should be conducted to investigate its long-term effects and potential for incorporation into standard care.

References

Ahn SY, Sung YH, Bae JH, et al(2022). Reliability and validity of the kinect-based mixed reality device: pilot study. Asian J Kinesiol, 24(2), 2-11. https://doi.org/10.15758/ajk.2022.24.2.2.

Baumann FT, Reike A, Reimer V, et al(2018). Effects of physical exercise on breast cancer-related secondary lymphedema: a systematic review. Breast Cancer Res Treat, 170(1), 1-13. https://doi.org/10.1007/s10549-018-4725-y.

Battaglini CL, Mills RC, Phillips BL, et al(2014). Twenty-five years of research on the effects of exercise training in breast cancer survivors: a systematic review of the literature. World J Clin Oncol, 5(2), 177-190. https://doi.org/10.5306/wjco.v5.i2.177.

Boing L, Vieira MCS, Moratelli J, et al(2020). Effects of exercise on physical outcomes of breast cancer survivors receiving hormone therapy - a systematic review and meta-analysis. Maturitas, 141, 71-81. https://doi.org/10.1016/j.maturitas.2020.06.022.

Chun MY(2012). Validity and reliability of Korean version of international physical activity questionnaire short form in the elderly. Korean J Fam Med, 33(3), 144-151. https://doi.org/10.4082/kjfm.2012.33.3.144.

Courneya KS, Mackey JR, Bell GJ, et al(2003). Randomized controlled trial of exercise training in postmenopausal breast cancer survivors: cardiopulmonary and quality of life outcomes. J Clin Oncol, 21(9), 1660-1668. https://doi.org/10.1200/JCO.2003.04.093.

Craig CL, Marshall AL, Sjöström M, et al(2003). International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc, 35(8), 1381-1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB.

Dieli-Conwright CM, Courneya KS, Demark-W, et al(2018a). Aerobic and resistance exercise improves physical fitness, bone health, and quality of life in overweight and obese breast cancer survivors: a randomized controlled trial. Breast Cancer Res, 20(1), Printed Online. https://doi.org/10.1186/s13058-018-1051-6.

Dieli-Conwright CM, Parmentier JH, Sami N, et al(2018b). Adipose tissue inflammation in breast cancer survivors: effects of a 16-week combined aerobic and resistance exercise training intervention. Breast Cancer Res Treat, 168(1), 147-157. https://doi.org/10.1007/s10549-017-4576-y.

Eakin EG, Hayes SC, Haas MR, et al(2015). Healthy living after cancer: a dissemination and implementation study evaluating a telephone-delivered healthy lifestyle program for cancer survivors. BMC Cancer, 15, Printed Online. https://doi.org/10.1186/s12885-015-2003-5.

Gary L(2021). ACSM's guidelines for exercise testing and prescription. 11th ed, Philadelphia, Lippincott Williams & Wilkins, pp.450-454.

Hayes SC, Newton RU, Spence RR, et al(2019). The exercise and sports science Australia position statement: exercise medicine in cancer management. J Sci Med Sport, 22(11), 1175-1199. https://doi.org/10.1016/j.jsams.2019.05.003.

Hudak PL, Amadio PC, Bombardier C(1996). Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder, and head). Am J Ind Med, 29(6), 602-608. https://doi.org/10.1002/(SICI)1097-0274(199606)29:6<602::AID-AJIM4>3.0.CO;2-L.

Jester A, Harth A, Wind G, et al(2005). Disabilities of the arm, shoulder and hand (dash) questionnaire: determining functional activity profiles in patients with upper extremity disorders. J Hand Surg Br, 30(1), 23-28. https://doi.org/10.1016/j.jhsb.2004.08.008.

Jones LW, Eves ND, Haykowsky M, et al(2008). Cardiorespiratory exercise testing in clinical oncology research: systematic review and practice recommendations. Lancet Oncol, 9(8), 757-765. https://doi.org/10.1016/S1470-2045(08)70195-5.

Kang SY, Kim YS, Kim Z, et al(2020). Breast cancer statistics in Korea in 2017: data from a breast cancer registry. J Breast Cancer, 23(2), 115-128. https://doi.org/10.4048/jbc.2020.23.e24.

Lee JY, Lim JY, Oh JH, et al(2008). Cross-cultural adaptation and clinical evaluation of a Korean version of the disabilities of arm, shoulder, and hand outcome questionnaire (K-DASH). J Shoulder Elbow Surg, 17(4), 570-574. https://doi.org/10.1016/j.jse.2007.12.005.

McNeely ML, Campbell KL, Rowe BH, et al(2006). Effects of exercise on breast cancer patients and survivors: a systematic review and meta-analysis. CMAJ, 175(1), 34-41. https://doi.org/10.1503/cmaj.051073.

Mishra SI, Scherer RW, Snyder C, et al(2014). Are exercise programs effective for improving health-related quality of life among cancer survivors? a systematic review and meta-analysis. Oncol Nurs Forum, 41(6), E326-E342. https://doi.org/10.1188/14.ONF.E326-E342.

Mishra SI, Scherer RW, Geigle PM, et al(2012). Exercise interventions on health‐related quality of life for cancer survivors. Cochrane Database Syst Rev, 2012(8), Printed Online. https://doi.org/10.1002/14651858.CD007566.pub2.

Panchik D, Masco S, Zinnikas P, et al(2019). Effect of exercise on breast cancer-related lymphedema: what the lymphatic surgeon needs to know. J Reconstr Microsurg, 35(1), 37-45. https://doi.org/10.1055/s-0038-1660832.

Pate RR, Pratt M, Blair SN, et al(1995). Physical activity and public health: a recommendation from the centers for disease control and prevention and the American college of sports medicine. JAMA, 273(5), 402-407. https://doi.org/10.1001/jama.1995.03520290054029.

Pinto BM, Frierson GM, Rabin C, et al(2005). Home-based physical activity intervention for breast cancer patients. J Clin Oncol, 23(15), 3577-3587. https://doi.org/10.1200/JCO.2005.03.080.

Ritchie C, Trost SG, Brown W, et al(2005). Reliability and validity of physical fitness field tests for adults aged 55 to 70 years. J Sci Med Sport, 8(1), 61-70. https://doi.org/10.1016/S1440-2440(05)80025-8.

Schmitz KH, Courneya KS, Matthews C, et al(2010). American college of sports medicine roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc, 42(7), 1409–1426. https://doi.org/10.1249/MSS.0b013e3181e0c112.

Seo JS, Park HA, Kang JH, et al(2014). Obesity and obesity-related lifestyles of Korean breast cancer survivors. Korea J Health Promot, 14(3), 93-102. https://doi.org/10.15384/kjhp.2014.14.3.93.

Segal RJ, Reid RD, Courneya KS, et al(2003). Resistance exercise in men receiving androgen deprivation therapy for prostate cancer. J Clin Oncol, 21(9), 1653-1659. https://doi.org/10.1200/JCO.2003.09.534.

Sietsema KE, Stringer WW, Sue DY, et al(2020). Wasserman & Whipp's: principles of exercise testing and interpretation: including pathophysiology and clinical applications. 6th ed, Philadelphia, Lippincott Williams & Wilkins, pp.1-585.

Speck RM, Courneya KS, Mâsse LC, et al(2010). An update of controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. J Cancer Surviv, 4(2), 87-100. https://doi.org/10.1007/s11764-009-0110-5.

Speck RM, Courneya KS, Mâsse LC, et al(2011). Erratum to: an update of controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. J Cancer Surviv, 5, Printed Online. https://doi.org/10.007/s11764-009-0110-5.

Stout NL, Baima J, Swisher AK, et al(2017). A systematic review of exercise systematic reviews in the cancer literature (2005-2017). PM R, 9(9S2), S347-S384. https://doi.org/10.1016/j.pmrj.2017.07.074.

Sung H, Ferlay J, Siegel RL, et al(2021). Global cancer statistics 2020: globocan estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin, 71(3), 209-249. https://doi.org/10.3322/caac.21660.

Sykes K, Roberts A(2004). The chester step test—a simple yet effective tool for the prediction of aerobic capacity. Physiotherapy, 90(4), 183-188. https://doi.org/10.1016/j.physio.2004.03.008.

Velthuis MJ, Agasi-Idenburg SC, Aufdemkampe G, et al(2010). The effect of physical exercise on cancer-related fatigue during cancer treatment: a meta-analysis of randomised controlled trials. Clin Oncol, 22(3), 208-221. https://doi.org/10.1016/j.clon.2009.12.005.

Zhang X, Li Y, Liu D(2019). Effects of exercise on the quality of life in breast cancer patients: a systematic review of randomized controlled trials. Support Care Cancer, 27(1), 9-21. https://doi.org/10.1007/s00520-018-4363-2.

Korea Central Cancer Registry(2019). Ministry of health and welfare. Annual report of cancer statistics in Korea in, 2107. Available at http://www.mohw.go.kr/upload/viewer/skin/doc.html?fn=1593397380887_20200629112301.pdf&rs=/upload/viewer/result/202304/Accessed Decenber, 2019.