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A Case Study of XCO-Trainer Exercise on Shoulder Pain, Dysfunction, Range of Motion, Scapular Position in Women Who Have Undergone Breast Cancer Surgery

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Abstract

Purpose: *This study examined the effects of XCO-Trainer exercise on shoulder pain, dysfunction, range of motion, scapular position, and quality of life in women who had undergone breast cancer surgery.*

Method: *This study was carried out on 37 breast cancer survivors. The participants were divided randomly into an XCO-Trainer exercise group(XBG=16) and a general breast cancer group(GBG=15). Outcomes, such as the Quadruple Visual Analogue Scale(QVAS), Shoulder Pain and Disability Index(SPADI), range of motion(ROM), Scapular Index(SI), and Functional Assessment Cancer Therapy-Breast(FACT-B), were measured pre- and post- intervention for both groups.*

Results: *A significant improvement in pain, functional disability level, range of motion, scapular position, and quality of life was observed in both groups(p<.01). Significant differences in pain, functional disability level, range of motion, scapular position, and quality of life post-test were observed between the two groups(p<.01).*

Conclusion: *The XCO-Trainer exercise treatment has a positive effect on breast cancer patients.*

Keywords: ***Breast Cancer, FACT-B, QVAS, SI, XCO-Trainer***

1. Introduction

A total of 254,718 cancer cases occurred in 2019, with 134,180 males and 120,538 females. Statistics on the probability of cancer occurrence as of 2019 show that the life expectancy in Korea is up to 83 years old, and the probability of getting cancer if alive is 37.9%. It can take two people, and in the case of women, when the life expectancy is 87 years old, it is estimated that it will occur in 1 out of 3 people at 35.8%. When looking at the incidence of major cancers by gender, the number one cancer, excluding thyroid cancer, was lung cancer in men and breast cancer in women[1].

Breast cancer is classified into cancer that develops in parenchymal tissues, such as ducts and lobules, and cancer that develops in other interstitial tissues, depending on the site of occurrence. Breast cancer surgery is divided into breast surgery and axillary lymph node surgery. Breast surgery includes conservative mastectomy and total mastectomy, and axillary lymph node surgery includes axillary lymph node debridement and sentinel lymph node biopsy[1].

Postoperative management includes chemotherapy, targeted therapy, immunotherapy, and radiation therapy. After treatment among the physical changes, breast cancer patients complained the most about pain and joint range of motion, and more than 50% reported that pain-related quality of life decreased and they experienced depression[2].

In addition, nerves and muscles are damaged after surgery, resulting in pain in the shoulder joint, numbness in the arm, decreased flexibility of the shoulder joint, weakened muscle strength, and weakened grip strength[3].

After breast cancer patients undergo resection, the position of the shoulder blade is deformed due to the shortening of the pectoral muscles, limiting the function of the surrounding muscles. If this condition persists, the movement of the joints around the shoulder blade is restricted and the space below the peak is reduced, resulting in shoulder disease, and as the shoulder bends forward, kyphosis and rounded shoulder posture appear[4].

Breast cancer patients develop a rounded shoulder posture due to surgery, and shortening of the small pectoral muscle causes reduction of shoulder blade lift, downward tilt, and upward rotation. When compensatory exercise occurs, muscle strength decreases, and the movement and functional parts of the shoulder joint are restricted, causing discomfort in daily life[5].

Breast cancer patients have a negative psychological effect because they have fears of recurrence and metastasis even in the process of recovery after surgery, and suffer from depression due to a decrease in quality of life. In addition, it was said that due to the deterioration of the quality of life, it is impossible to play a role as a member of the family and society, and it is difficult to recover from the normal life[6].

It has been reported that physical activity should be promoted to manage and recover physical function damage after breast cancer surgery, and that aerobic exercise such as aquatic exercise is good for arm function training[7].

Eom reported that, as a result of applying Tai Chi exercise to breast cancer patients, the range of motion and functional impairment of the arm improved after 12 weeks, and the quality of life improved[8].

Kang and Yoon reported that complex water exercise As a result of application for 8 weeks, it was said that the experimental group improved shoulder dysfunction and showed a significant difference in forced lung capacity[9].

The XCO-Trainer is versatile. In the rehabilitation part, it is used for rehabilitation purposes, and in sports training, it is used to improve sports skills and performance of athletes. It is also used for muscle stabilization and balance training in balance and coordination training, and is used for core strengthening training. Finally, in group fitness classes, various exercises and intensities are applied to increase muscle interaction and are used for aerobic exercise.

The main difference between the XCO-Trainer and regular dumbbells is the way they provide resistance during exercise. The XCO-Trainer uses an internal reactive mass that creates a vibrating effect, whereas regular dumbbells rely on the weight of the equipment itself to provide resistance. Additionally, the XCO-Trainer is suitable for a wide range of exercises including squats, lunges, rotations and more, while regular dumbbells are commonly used for individual exercises targeting specific muscles.

There was no previous study in Korea that applied XCO-Trainer exercise to affect the shoulder joint in women who had undergone breast cancer resection. Therefore, the purpose of this study is to investigate the XCO-Trainer exercise on the shoulder joint, pain, functional disability, joint range of motion, and shoulder blade posture in women who underwent breast cancer surgery.

The specific hypotheses of this study are as follows. First, when comparing the XCO-Trainer exercise group and the general physical therapy group before and after the intervention, there will be differences in shoulder joint pain, functional disability, range of motion, shoulder blade posture, and quality of life. Second, there will be differences in the post-intervention values of shoulder joint pain, functional disability, range of motion, scapular posture, and quality of life between the two groups before and after the intervention compared to the XCO-Trainer exercise group and the general physical therapy group.

2. Methods

2.1. Research subject

The subjects of this study were patients who visited the hospital for treatment after undergoing breast cancer surgery at D University Oriental Medicine Hospital. It was conducted from January 10, 2022 to June 17, 2022. The subjects were 40 in total, and 37 subjects who met the selection and exclusion conditions were conducted. After explaining the study, participants who clearly understood the contents and gave consent were allowed to voluntarily participate in the experiment. The selection conditions for the subjects were: 1)women aged 35 years or older, 2)women who had passed more than 4 weeks after breast cancer surgery, 3)women who were prescribed manual therapy at the hospital, 4)pain scale at the pain reference point scale(quadruple visual analogue scale; QVAS) A woman with a total score of 3 or more was selected as a woman who personally agreed after listening to an explanation before starting the fifth study.

2.2. Experiment tools and measurement methods

Before applying the exercise therapy intervention to the study subjects, general characteristics, shoulder joint pain, arm dysfunction, range of motion, shoulder blade posture, and quality of life were evaluated.

2.2.1. Experimental design and method

After preliminary evaluation, 40 subjects were randomly assigned to the 20 XCO-Trainer exercise groups(XCO-Trainer exercise group; XBG) and 17 general physical therapy groups(general breast cancer group; GBG), and experiments and evaluations were conducted. In the XBG group, XCO-Trainer exercise was applied as an intervention after general physical therapy, and in the GBG group, only general physical therapy was applied. The intervention program of the two groups was conducted for 4 weeks, and the evaluation of the two groups was conducted before and after the intervention. The design of the study is as follows <Figure 1>.

2.2.2. Arbitration method

This study was an exercise using an XCO-Trainer(XCO medium, XCO, Netherlands), and 3 exercises were performed while holding the XCO-Trainer with one hand. In addition, a total of 7 sets were composed by repeating the 3 exercises, and each set was exercised for 20 seconds and had a 1 minute break. Also, when you start holding the XCO-Trainer, spread your legs one step wider than shoulder width, apply strength to your stomach, bend your knees, and start in a standing position <Figure 2>. The exercise program was constructed by referring to the thesis of Morat et al[10], and the thesis of Son[11]. XCO-Trainer was developed over 16 years by Jan, a physical therapist from the Netherlands. The movement principle of the XCO-Trainer has a moving mass composed of very special and irregular particles inside, so it has the movement of Delayed Impact, Soft Impact, and Reactive Impact. Delayed Impact is a movement that allows all particles inside to move smoothly without moving simultaneously when moving with the XCO-Trainer. Soft Impact is a movement that allows you to reach the end point of the XCO-Trainer without straining your joints. Reactive Impact can be described as a movement that produces the same effect as an exercise in a stretched state when the movement is continued, that is, plyometrically. The types of XCO-Trainer consist of a total of 4 types: extra small, small, medium, and large. The product used as an intervention method is a medium product, with a weight of 900g, special particle weight of 600g, length of 42.5cm, diameter of 5cm, and the color is red <Figure 2>. Also, the advantages of the XCO-Trainer are that you can do strength training without straining your joints, it can be done anywhere, it is convenient to manage and store, and it is possible to exercise the whole body along with walking or running.

Figure 1. 8-week physiotherapy and XCO exercise study design.

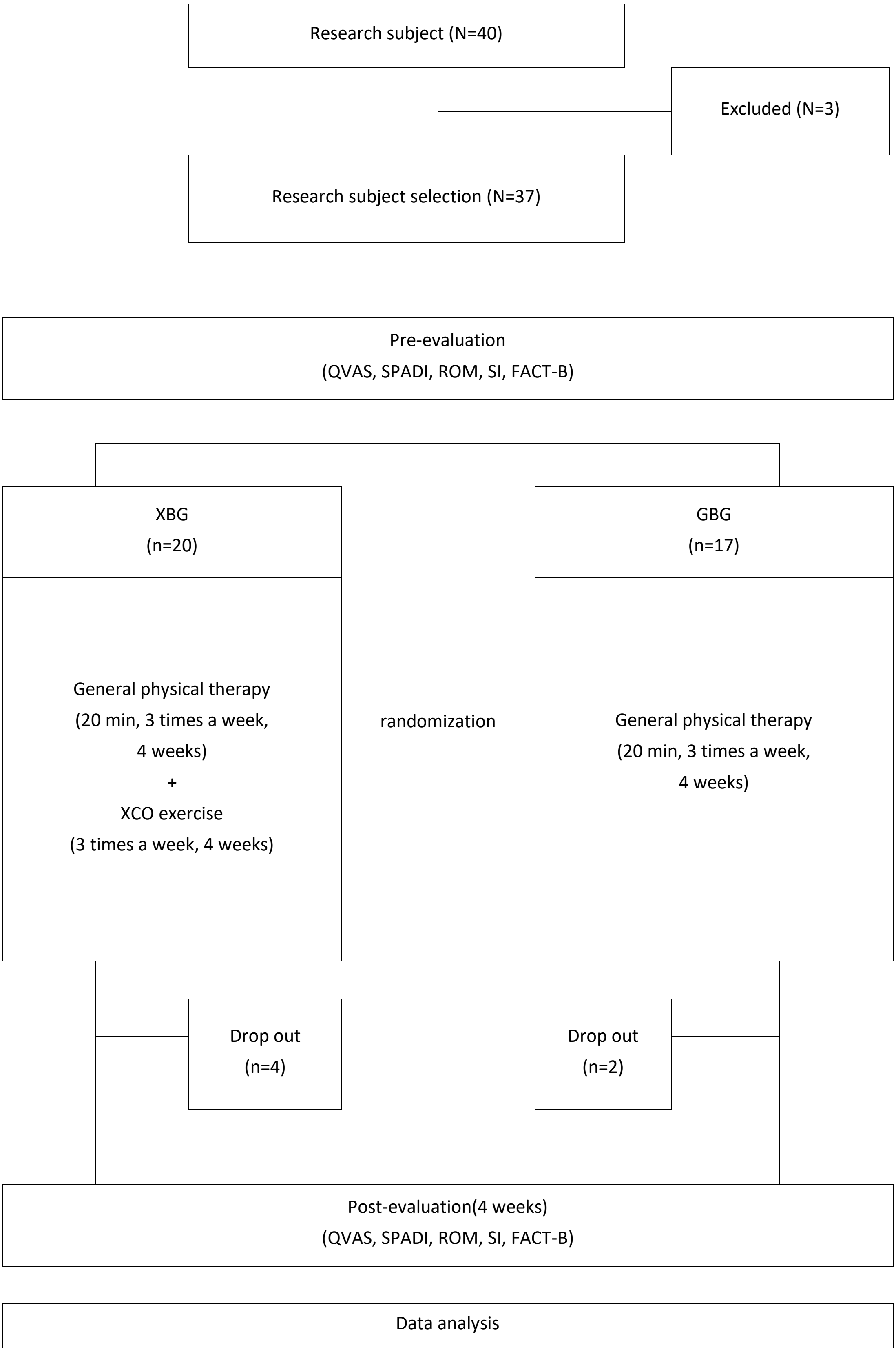


Figure 2. XCO-trainer medium size.

① Flexion shake exercise

In the first action, after taking the posture before the start, hold the XCO-Trainer and raise your arms parallelly so that your shoulders are at 90 degrees. In the second action, while holding the XCO-Trainer, raise your arms above your head and stretch your arms so that your ears and arms are in a straight line. For the third motion, repeat the first and second motions for 20 seconds, shake them up and down, and then take a break for 1 minute <Figure 3>.

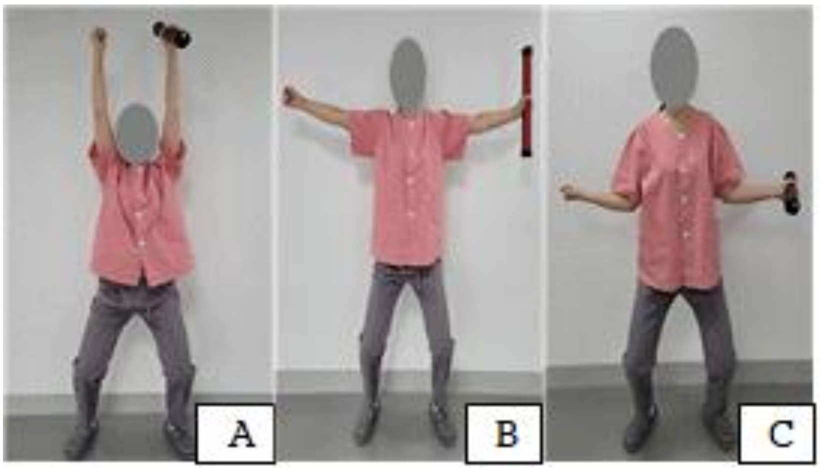
② Abduction shake exercise

In the first action, after taking the posture before the start, hold the XCO-Trainer and raise your arms parallel to the side so that your shoulders are 90 degrees. In the second action, while holding the XCO-Trainer, raise your arms above your head and stretch your arms so that your ears and arms are in a straight line. For the third motion, repeat the first and second motions for 20 seconds, shake them up and down, and then take a break for 1 minute <Figure 3>.

③ External rotation shake exercise

For the first action, after taking the posture before the start, bend your elbows to 90 degrees and hold the XCO-Trainer. The second action extends the arms outward from the body while holding the XCO-Trainer. The third motion repeats the first and second motions for 20 seconds, shakes them sideways, and then rests for 1 minute <Figure 3>.

Figure 3. XCO-trainer exercise.



Note: A: Flexion shake exercise, B: Abduction shake exercise, C: External rotation.

2.3. Measure

2.3.1. Pain level

A 4-item quadruple visual analogue scale(QVAS) was used as an evaluation tool for the pain level of the subject's shoulder joint. This evaluation tool consists of a total of four items, each of which includes: (1)what is the current pain level, (2)what is the average level of pain experienced usually, and (3)what is the lowest level of pain. Fourth, it is composed of questions about what level of pain is the most severe. For each question, “0” was placed on a horizontal line ranging from 0 to 10 cm, with 0 indicating no pain and 10 indicating the most severe pain. 0cm was scored as 0 points, and 10cm was scored as 10 points, and the scores for the questions on a total of four items were summed and averaged, and the values were multiplied by 10. On the QVAS, a high total score indicates severe pain[12]. The reliability of this evaluation tool is r=.76~.84[13].

2.3.2. Level of dysfunction

To evaluate the level of arm dysfunction of the study subjects, the shoulder pain and disability index(SPADI) was used. The composition of this evaluation sheet is divided into two categories, the degree of pain and the degree of discomfort. The degree of pain is divided into 5 questions and the degree of discomfort is divided into 8 questions, for a total of 13 questions. A score of 0 means no pain or no functional discomfort at all, and a score of 10 indicates very severe pain or very severe discomfort. he total score was the average value obtained by adding the scores of the 13 items. The higher the score on the SPADI, the worse the dysfunction of the arm is[14]. The reliability of SPADI is ICC=.99, showing high reliability[15].

2.3.3. Shoulder range of motion

When measuring the range of motion(ROM) of the shoulder joint of the study subjects, it was measured in two postures. In the first posture, the angles of flexion, extension, and abduction were measured in the upright posture, and in the second posture, the angles of internal and external rotation were measured in the supine posture. A bubble inclinometer(Baseline, USA) was used as a measurement tool. The reliability of the bubble inclinometer is ICC=.95[16]. In order to measure the exact angle, the angles of bending, extension, abduction, internal rotation, and external rotation were measured twice, and the average value was used. In addition, in order to prevent the compensatory action that can occur from all angles, the shoulders were attached to the wall in the standing position and the shoulders did not come off the floor in the lying position. If a compensation action occurred during the measurement, the evaluation was conducted again. The bending angle was measured at the front center of the upper arm, the extension angle was measured at the back center of the upper arm, and the abduction angle was measured at the center of the deltoid muscle central fiber. The medial and lateral rotation angles were measured at the center of the forearm[16].

2.3.4. Assessment of shoulder blade position

The scapular index(SI) was used to evaluate the subject's scapular posture. When measuring the scapular index(SI), it was performed twice each on the right and left sides, and the average value was used. A tape measure(rollfix, hoechstmass, germany) was used as a measurement tool. The method to evaluate the SI was the distance from the midpoint of the sternal notch(SN) to the medial surface of the coracoid process(CP) of the scapula(SN-CP) and the 3rd thoracic vertebra The distance from the 3 thoracic spine(3TS) to the posterolateral angle of the acromion(PLA)(TS-PLA) was measured. In order to measure the distance of the SN-CP on the operated side from the front, the SN and CP points were marked with a sticker and measured twice each. In order to measure the distance of the 3TS-PLA on the operated side from the back, the 3TS and PLA areas were marked with stickers and measured twice. The way to calculate SI is

SI=(SN-CP/TS-PLA)×100[17]. In order to accurately measure the lengths of SN-CP and 3TS-PLA, the average value was used by measuring twice, and the average value was used by obtaining the value twice for accurate measurement of the SI value. The larger the value of SI, the more shoulder external rotation, scapular retraction, or adduction, and the smaller the value, the more shoulder internal rotation, or scapular protraction, or abduction[18]. The reliability of the SI shows high reliability with ICC=.96 on the right side and ICC=.93 on the left side[19].

2.3.5. Quality of life level

A functional assessment cancer therapy-breast(FACT-B) was used to evaluate the quality of life of the study subjects. This evaluation tool used a method in which the patient himself read the questionnaire and marked 'V' in the number, and the same measurer measured it. FACT-B consists of a total of 38 questions with 5 items: socio-familial status, physical status, emotional status, functional status, and other status. FACT-B uses a 5-point scale in the form of 0 to 4 points, with 0 points meaning 'not at all' and 4 points meaning 'very much so'. The physical state is about disease symptoms and side effects of treatment, the socio-familial state is about the quality of communication and relationships with acquaintances and family, the emotional state is about the psychological part of breast cancer patients and their attitude toward the disease, and the functional state is to evaluate activities and roles in daily life, and other conditions are to evaluate my current condition due to breast cancer[20]. The score of FACT-B is evaluated by summing the scores for each question in each submission, calculating the total score, multiplying by the number of questions, and dividing by the number of questions answered. The inverse questions are the questions of physical condition, questions '1,3,4,5,6' for normal conditions, and questions '1,2,3,5,6,7,8,9,10' for other conditions. to be. The reliability of FACT-B shows high reliability with ICC=.90[21].

2.4. Analysis method

Statistical analysis of this study used SPSS Ver 21.0 for Windows. Statistical analysis of the study was performed using SPSS Ver 21.0 for Windows. The general characteristics of the study subjects were analyzed using descriptive statistics. Kolmogorov-Smirnov test method was used for normality test, paired t-test was used to compare the difference between the two groups before and after the intervention, and independent t-test was used to compare the difference between the two groups. The significance level was set to α=.05.

3. Result

3.1. General characteristics of research subjects

A total of 40 subjects participated in the study, 20 in the XBG group and 17 in the GBG group. There were 4 dropouts in the XBG group and 2 in the GBG group. There were 16 patients in the XBG group and 15 patients in the GBG group. The average age of the study subjects was 49.23±8.90 years and the average weight was 56.52±5.64 kg, and the average height was 162.81±4.61 cm. There were 13 right arm and 3 left arm in the XBG group, and 13 right arm and 3 left arm in the GBG group, showing no significant difference. In addition, the surgical sites between the two groups were right and left in 8 patients in the XBG group, and right in 6 patients and left in 9 patients in the GBG group, and there was no significant difference between the two groups. The operation time between the two groups was 33.75±6.98 weeks in the XBG group and 33.20±3.75 weeks in the GBG group, showing no significant difference. The time of onset of pain was 13.38±5.75 weeks in the XBG group and 11.67±5.19 weeks in the GBG group, showing no significant difference. As for the cause of pain, chemotherapy was used in 10 patients and 6 patients in the XBG group, and chemotherapy was used in 10 patients and surgery was performed in 6 patients in the GBG group <Table 1> .

Table 1. General characteristics of study participants.

	XBG(n=16)[a]	GBG(n=15)[b]	F
Age(yers)	49.44±7.62[c]	49.00±10.36	.89
Weight(㎏)	57.75±5.99	55.20±5.12	.21
Height(㎝)	161.38±4.16	164.33±4.72	.07
Dominant arm(R/L)[d]	13/3	13/2	.30
Mastectomy(R/L)[e]	8/8	6/9	.16
Surgery time(weeks)	33.75±6.98	33.20±3.75	.79
Pain time(weeks)	13.38±5.75	11.67±5.19	.39
Pain reason(①/②)[f]	10/6	10/6	.25

Note: [a]XBG: xco-trainer exercise breast cancer group, [b]GBG: general breast cancer group, [c]Mean±SD, [d]R: right/L: left, [e]R: right/L: left, [f]①: anticancer treatment ②: surgery.

3.2. Comparison of pain and functional impairment level evaluation between the two groups

In the QVAS there was a significant difference when comparing the before and after differences between the XBG group and the GBG group(p<.01). When comparing the difference before and after within the XBG group and the GBG group, there was a significant decrease(p<.01). The XBG group decreased significantly by 2.59±0.92 after the intervention than before the intervention(p<.01) <Table2 >.

As for the level of functional disability, there was a significant second baby when comparing the pre- and post-war differences between the XBG group and the GBG group(p<.01). Significantly decreased in each group(p<.01). XBG group decreased more than GBG group(p<.01). The XGB group significantly decreased to 2.91±1.11 after intervention(p<.01) <Table 2>.

3.3. Comparison of range of motion of the shoulder joint between the XBG group and the GBG group

When comparing the anteroposterior difference between the XBG group and the GBG group, the joint range of motion in flexion, extension, abduction, and lateral rotation significantly increased(p<.01). In the difference between the two groups before and after, internal rotation increased the joint range of motion, but there was no significant difference. In addition, there was a significant difference in the bending angle of the XBF group and the GBG group before intervention(p<.01). When comparing the anteroposterior difference between the two groups, the joint range of motion for flexion, extension, abduction, external rotation, and internal rotation significantly increased. When comparing the difference between before and after within the group, the joint range of motion for flexion, extension, abduction, external rotation, and internal rotation significantly increased(p<.01). In the XBG group, flexion increased to 28.33±4.92, extension increased to 13.91±3.12, abduction increased to 24.71±8.12, external rotation increased to 20.25±5.70 and Internal rotation was significantly increased to 10.72±1.66(p<.01) <Table 3>.

Table 2. Comparison of shoulder pain and dysfunction level in two group.

		XBG(n=16)[a]	GBG(n=15)[b]	t	p
QVAS[e]	Pre	6.54±0.62[c]	6.52±0.87	0.10	.92
	Post	3.95±1.07	5.70±0.82	5.06	.00†
	Diff[d]	2.59±0.92	0.82±0.33	7.04	.00†
	t	11.25**	9.75**		

SPADI[f]	Pre	6.57±0.58	6.46±0.78	0.43	.67
	Post	4.01±0.86	5.13±1.07	3.21	.00†
	Diff	2.91±1.11	1.33±0.66	4.79	.00†
	t	12.13**	7.77**		

Note:[a]XBG: xco-trainer exercise breast cancer group, [b]GBG: general breast cancer group, [c]Mean±SD, [d]difference, [e]QVAS: quadraple visual analogue scale, [f]SPADI: shoulder pain and disability index, *p<.05, **p<.01, †there is a significant difference when compared with the GBG group(p<0.1).

3.4. Comparison of posture evaluation and quality of life evaluation between the two groups

There was a significant difference in the position evaluation of the scapula when comparing the anterior and posterior differences between the XBG group and the GBG group(p<.01). When comparing the difference before and after within the XBG group and the GBG group, there was a significant increase(p<.01). XBG group increased significantly more than GBG group(p<.01). The XBG group increased significantly to 8.35±1.09 after the intervention than before the intervention(p<.01) <Table 4>.

In the quality of life evaluation, there was a significant difference when comparing the before and after differences between the XBG group and the GBG group(p<.01). Significantly increased in XBG and GBG groups(p<.01). XBG group increased significantly more than GBG group(p<.01). The XBG group increased significantly by 10.74±1.82 after the intervention than before the intervention(p<.01) <Table 4>.

Table 3. Comparison of shoulder range of motion the XCO-trainer exercise breast cancer and general breast cancer group.

		XBG(n=16)[a]	GBG(n=15)[b]	t	p
Flex[e]	Pre	109.58±9.40[c]	98.67±7.19	3.42	.00†
	Post	137.92±6.20	109.00±8.23	10.08	.00†
	Diff[d]	28.33±4.92	10.33±4.64	9.75	.00†
	t	19.9**	8.6**		
Ext[f]	Pre	27.00±6.79	26.43±4.47	0.26	.80
	Post	40.91±6.43	32.89±4.48	3.82	.00†
	Diff	13.91±3.12	6.46±1.55	8.11	.00†
	t	15.45**	16.12**		
Abd[g]	Pre	100.08±7.45	101.00±9.30	0.28	0.78
	Post	124.79±11.02	109.83±9.67	3.75	.00†
	Diff	24.71±8.12	8.83±2.54	7.18	.00†
	t	10.54**	13.47**		
Ext-ro[h]	Pre	25.92±7.18	30.47±7.77	1.56	.13
	Post	46.17±6.93	36.33±8.23	3.31	.00†
	Diff	20.25±5.70	5.87±1.68	9.32	.00†
	t	12.31**	13.49**		
In-ro[i]	Pre	31.79±6.36	31.07±7.69	0.26	.80
	Post	42.51±6.43	36.89±8.19	1.94	.06
	Diff	10.72±1.66	5.82±0.78	10.15	.00†
	t	22.41**	28.75**		

Note: aXBG: xco-trainer exercise breast cancer group, bGBG: general breast cancer group, cMean±SD, ddifference, eFlexion, fExtension, gAbduction, gExternal rotation, iInternal rotation *p<.05, **p<.01, †there is a significant difference when compared with the GBG group(p<0.1).

Table 4. Comparison of upper extremity posture and dysfunction level in two group.

		XBG(n=16)[a]	GBG(n=15)[b]	t	p
SI[e]	Pre	66.91±3.92[c]	66.15±2.83	0.61	.55
	Post	75.26±3.75	69.78±2.92	4.52	.00†
	Diff[d]	8.35±1.09	3.63±1.03	12.40	.00†
	t	30.73**	13.64**		
FACT-B[f]	Pre	63.08±4.91	60.40±4.32	1.61	.12
	Post	73.83±5.62	64.23±3.97	5.45	.00†
	Diff	10.74±1.82	3.83±0.82	13.49	.00†
	t	23.63**	18.20**		

Note: aXBG: xco-trainer exercise breast cancer group, bGBG: general breast cancer group, cMean±SD, ddifference, eSI: scapular index, fFACT-B: functional assessment cancer therapy-breast, *p<.05, **p<.01, †there is a significant difference when compared with the GBG group (p<0.1).

4. Discussion

This study was conducted to investigate changes in shoulder joint posture after XCO-Trainer exercise in women who had undergone breast cancer resection. As a result of the study, there was a significant difference when comparing the before and after differences in shoulder joint pain, functional disability, range of motion, shoulder blade posture, and quality of life.

There was a significant difference in pain when comparing the difference before and after in the two groups(p<.01), and there was also a significant difference within the two groups(p<.01). As a result of applying compound exercise for 4 weeks to 14 patients who underwent breast cancer surgery, pain in the arm decreased after 4 weeks compared to before. In the range of motion of the shoulder joint, it has been reported that there are significant differences in flexion, extension, abduction, deflection, external rotation, and medial rotation, excluding extension[22]. In addition, as a result of applying exercise therapy to 40 patients undergoing radiation therapy after breast cancer surgery, the group in which exercise therapy was applied together with radiation therapy showed a significant reduction in pain[23]. In order to reduce joint pain and swelling, muscle cross-extension is used to induce contraction of the opposite muscle, and when the agonist contracts, the antagonist muscle relaxes, so that the inflamed muscles do not contract and maintain normal tension, reducing the inflammatory response[24].

There was a significant difference in the level of functional disability when comparing the difference before and after the XBG group and the GBG group(p<.01). There was a significant difference when comparing the difference before and after within each group(P<.01). Portela et al[25]. found that when a combination of aerobic and resistance exercise was performed at home or at a gym, the range of motion of the arm in women who had breast cancer surgery increased, and women with upper extremity lymphedema also strengthened their upper extremity function, improving daily life. It is reported that they are living without difficulties in life. In addition, as a result of a 6-month follow-up examination for women who had undergone breast cancer resection, it was found that the range of motion of the shoulder joint and the functional disability score of the arm were gradually improving. Due to this figure, it is reported that breast cancer patients show that the function of the shoulder joint is increasing over time[26]. Through various compound exercises, it is estimated that the structures around the shoulder joint have the effect of increasing the movement of the shoulder joint by maximizing the stability of the shoulder joint due to the muscles connected to the far and near sides[27].

When comparing the anteroposterior difference between the XBG group and the GBG group, there was a significant difference in all angles except medial rotation for the range of motion of the shoulder joint(p<.01). In addition, when comparing the difference before and after within the two groups, there was a significant difference at all angles(p<.01). Among women who underwent breast cancer surgery, 52 women were randomly selected to exercise belly dance and Pilates for 16 weeks. As a result, the range of motion of the shoulder joint significantly increased. It has been reported that it has a positive effect on daily life and affects the quality of life[28]. In addition, Lobardi et al performed scapular stabilization exercises and stretching on the shoulder joint simultaneously for 2 months, and as a result, there was a significant difference in the joint range of motion, such as flexion, extension, abduction, external rotation, and medial rotation angles[29]. It has been reported that the angle of extension and abduction increases significantly. The shoulder joint is the most unstable joint in the human body, and if the muscles around the shoulder are restricted due to the cooperative control of the surrounding tissues, the range of motion of the joint is also affected, which can cause the movement of the shoulder joint to be limited[30].

There was a significant difference in the position of the shoulder blade when comparing the anteroposterior difference between the XBG group and the GBG group(p<.01). When comparing the difference before and after in the XBG group and the BGB group, there was a significant increase(p<.01). As a result of applying scapular stabilization exercise for 6 weeks to 16 patients who underwent breast cancer surgery, there was a significant difference in SI. When comparing the difference before and after exercise, it has been reported that there was a significant difference between the SN and CP distance and SI[31]. In addition, as a result of training for 47 patients with shoulder impingement syndrome for 6 weeks, it has been reported that the MVIC of the trapezius muscle and serratus anterior muscles around the shoulder significantly decreased and the movement of the scapula was also stabilized[32]. When breast cancer resection is performed, the length of the pectoralis minor muscle is shortened, resulting in shortening, and the correct posture of the scapula, which is internal rotation, upward inclination, external rotation, extrusion, and depression, deviates from the normal alignment of the scapula. In addition, the position of the scapula affects the angle formed in the concave humerus, the distance from the head of the humerus to the shoulder peak, and the space below the peak of the shoulder blade[33].

There was a significant difference in quality of life when comparing the before and after differences between the XBG group and the GBG group(p<.01). In addition, there was a significant increase in both groups(p<.01). After undergoing breast cancer surgery, mindfulness yoga was performed for 6 weeks on 17 patients who voluntarily participated. It has been reported that the quality of sleep has also improved[34]. In addition, as a result of applying the meditation program to breast cancer patients to a total of 42 patients for 7 months, the right anxiety and depression scores were lowered, and the quality of life score was also increased, indicating that the quality of life was very improved, and it was reported that the patient's power was also increased[35]. Gautam et al reported that the quality of life improved and the circumference of lymphedema decreased as a result of applying strength training and breathing exercise to 32 people at home for 8 weeks[36].

In this study, when XCO-Trainer exercise was applied to women who underwent breast cancer surgery, it was found to relieve shoulder joint pain, reduce functional disability, increase shoulder joint range of motion, correct shoulder posture, and improve quality of life.

The limitations of this study are: First, bilateral breast cancer subjects were excluded in the selection of subjects. Second, it is difficult to apply to all breast cancer patients because the study targeted patients who visited hospitals in a limited area. Third, it cannot be ruled out that the XBG group and the GBG group were affected by the difference between the time of surgery and the time when pain started. Fourth, it is difficult to apply to all breast cancer patients because the target is set to patients who can recognize the explanation. Fifth, since the age group of women who underwent breast cancer surgery was set at 30 years of age or older, it is difficult to apply it to all age groups. Therefore, in order to restore pain, functional, physical, and psychological functions to women who have undergone breast cancer resection, therapeutic intervention is continuously required, and preventive treatment through various interventions is considered to be necessary.

5. Conclusion

In this study, 37 women who underwent breast cancer resection were subjected to XBG group(16 patients), 20 minutes of general physical therapy 3 times a week for 4 weeks, followed by XCO exercise as an intervention, and GBG group(15 patients). Only general physical therapy was applied as an intervention three times a week for four weeks, and the effect on shoulder joint pain, functional disability, range of motion, shoulder blade posture, and quality of life before and after intervention was investigated. The conclusions from that are as follows.

1. The group that applied the XCO-Trainer exercise showed a significant decrease in pain. There was a significant difference when comparing the difference before and after within each group.
2. The group to which XCO-Trainer exercise was applied showed a significant decrease in the level of functional disability. There was also a significant difference in comparison of before and after differences between the two groups.
3. In the group applying the XCO-Trainer exercise, all angles increased in the range of joint motion, but there was no significant difference only in internal rotation. There was a significant difference when comparing the difference before and after within each group.
4. The group applying the XCO-Trainer exercise showed a significant increase in the shoulder blade posture. There was a significant difference when comparing the difference before and after in the two groups.
5. The group that applied the XCO-Trainer exercise significantly increased the quality of life. There was a significant difference when comparing the difference before and after within each group.

The group that applied the XCO-Trainer exercise significantly increased the quality of life. There was a significant difference when comparing the difference before and after within each group. Continuous and scientific follow-up research on XCO-Trainer according to types of sports performance rehabilitation training, balance and coordination training, core strengthening, and cardiovascular conditioning is needed.

6. References

6.1. Journal articles

[2] Andrea AL & Cheville MD & Julia T. Barriers Rehabilitation Following Surgery for Primary Breast Cancer. *Journal of Surgical Oncology*, 95(5), 409-418 (2007).
[3] Bassem TE & Eric RW & Jean DW & Malo L & Julia L. Outcome of Reverse Shoulder Arthroplasty with Pedicled Pectoralis Transfer in Patients with Deltoid Paralysis. *Journal of Shoulder and Elbow Surgery*, 27(1), 96-103 (2018).

[4] Johnson AJ & Godges JJ & Zimmerman GJ. The Effect of Anterior Versus Posterior Glide Joint Mobilization on External Rotation Range of Motion in Patients with Shoulder Adhesive Capsulitis. *Journal of Orthopaedic & Sports Physical Therapy*, 7(3), 88-99 (2007).
[5] Borstad JD & Ludewig PM. The Effect of Long Versus Short Pectoralis Minor Resting Length on Scapular Linematics in Healthy Individuals. *Journal of Orthopaedic & Sports Physical Therapy*, 35(4), 227-238 (2005).
[6] Wonghongkul T & Moore SM & Musil C. The Influence of Uncertainty in Illness, Stress Appraisal, and Hope on Coping in Survivors of Breast Cancer. *Cancer Nursing*, 23(6), 422-429 (2000).
[7] Pinto BM & Frierson GM & Rabin C. Home-based Physical Activity Intervention for Breast Cancer Patients. *Journal of Clinical Oncology*, 23(15), 3677-3587 (2005).
[9] Kang YH & Yoon JH. The Effect of Convergent Aquatic Exercise on Shoulder and Pulmonary Function and Quality of Life in Breast Cancer Patients. *Journal of Digital Convergence*, 19(10), 349-355 (2021).
[10] Morat TM & Krueger J & Gaedtke A. Effects of 12 Weeks of Nordic Walking and XCO Walking Training on the Endurance Capacity of Older Adults. *European Review of Aging and Physical Activity*, 14, 16-16 (2017).
[12] Von MK & Deyo RA & Cherkin D. Back Pain in Primary Care. Outcomes at 1 year. *Journal of Spine*, 18(7), 855-862 (1993).
[13] Boonstra M & Malefijt MDW & Verdonschot N. How to Quantify Knee Function after Total Knee Arthroplasty?. *The Knee*, 15(5), 390-395 (2008).
[14] Roach KE & Budiman-Mak E & Songsiridej N. Development of a Shoulder Pain and Disability Index. *Arthritis & Rheumatism*, 4(4), 143-149 (1991).
[15] Seo HD & Lee KW & Jung KS. Reliability and Validity of the Korean Version of Shoulder Pain and Disability Index. *Journal of Special Education & Rehablition Science*, 51(2), 319-336 (2012).
[16] Pringle RK. Intra-instrument Reliability of 4 Goniometers. *Journal of Chiropractic Medicine*, 2(3), 91-95 (2003).
[17] Borstad JD. Resting Position Variables at the Shoulder: Evidence to Support a Posture-impairment Association. *Physical Therapy*, 86(4), 49-557 (2006).
[18] Borstad JD & Szucs KA. Three-dimensional Scapula Kinematics and Shoulder Function Examined before and after Surgical Treatment for Breast Cancer. *Human Movement Science*, 31(2), 408-418 (2012).
[19] Lee MJ & Kim SY & Shim JK. Comparison of Shoulder Range of Motion Pain, Function, Scapular Position between Breast Cancer Surgery and Shoulder Surgery Female Patients. *Physical Therapy Korea*, 22(1), 9-18 (2015).
[20] Cella D. Assessment Methods for Quality of Life in Cancer Patients: The FACIT Measurement System. *International Journal of Pharmaceutical Medicine Volume*, 14, 78-81 (2001).
[21] Yoo HJ & Ahn SA & Eremenco S. Korean Translation and Validation of the Functional Assessment of Cancer Therapy-breast(FACT-B) Scale Version 4. *Quality of Life Research*, 14(6), 1627-1632 (2005).
[22] Lee BK & Lee JS & Kim TS. The Influence of 4 Weeks Complex Therapeutic Exercises on Visual Analog Scale of Pain and Range of Motion for Middle-aged Women with Breast Cancer-related Lymphedema. *Journal of the Korean Society of Physical Medicine*, 8(2), 153-161 (2013).
[23] Hwang JH & Chang HJ & Shim YH. Effects of Supervised Exercise Therapy in Patients Receiving Radiotherapy for Breast Cancer. *Yonsei Medical Journal*, 49(3), 443-450 (2008).
[24] David NL. Sherrington's The Integrative Action of the Nervous System: A Centennial Appraisal. *Journal of the Neurological Sciences*, 253(1), 1-6 (2007).
[25] Portela AL & Santaella CL & Gomez CC. Feasibility of an Exercise Program for Puerto Rican Women Who are Breast Cancer Survivors. *Rehabilitation oncology*, 26(2), 20-31 (2008).
[26] Cho OH. Effects of a Comprehensive Rehabilitation Program for Mastectomy Patients. *Journal of Korea Academy of Nursing*, 34(5), 809-819 (2004).

[27] Oliver GD & Sola M & Dougherty C & Huddleston S. Quantitative Examination of Upper and Lower Extremity Muscle Activation during Common Shoulder Rehabilitation Exercise using the Bodyblade. *Journal of Strength and Conditioning Research*, 27(9), 2509-2517 (2013).
[28] Leite B & Fretta TB & Boing L. Can Belly Dance and Mat Pilates be Effective for Range of Motion, Self-esteem, and Depressive Symptoms of Breast Cancer Women?. *Complementary Therapies in Clinical Practice*, 45, 101483-101483 (2021).
[29] Lombardi JR & Magri AG & Fleury AM. Progressive Resistance Training in Patients with Shoulder Impingement Syndrome: A Randomized Controlled Trial. *Arthritis Care & Research: Arthritis Rheumatol*, 59(5), 615-622 (2008).
[30] Jung BF & Herrmann D & Griggs J. Neuropathic Pain Associated with Non-surgical Treatment of Breast Cancer. *International Association for the Study of Pain*, 118(1), 10-14 (2005).
[32] DeMey K & Danneels L & Cagnie B. Scapular Muscle Rehabilitation Exercises in Overhead Athletes with Impingement Symptoms: Effect of a 6-week Training Program on Muscle Recruitment and Functional Outcome. *American Journal of Sports Medicine*, 40(8), 1906-1915 (2012).
[33] Kibler WB. The Role of the Scapula in Athletic Shoulder Function. *The American Journal of Sports Medicine*, 26(2), 325-337 (1998).
[34] Yook YS & Yu BH & Kim JH. The Effects of Mindfulness Yoga Program on Quality of Life in Breast Cancer Survivors. *Korean Journal of Sport Psychology*, 25(4), 55-69 (2014).
[35] Jang SJ. Effect of Meditation Program on Power, Anxiety, Depression and Quality of Life in Women with Breast Cancer. *Journal of Korean Academy of Psychiatric and Mental Health Nursing*, 22(3), 205-215 (2013).
[36] Gautam AP & Maiya AG & Vidyasagar MS. Effect of Home-based Exercise Program on Lymphedema and Quality of Life in Female Postmastectomy Patients: Pre-post Intervention Study. *Journal of Rehabilitation Research & Development*, 48(10), 1261-1268 (2011).

6.2. Thesis degree

[8] Eom AY. Development and Application of Early Rehabilitation Program using Yang-style Tai Chi Exercise for Breast Cancer Patients after Mastectomy. Seoul National University, Doctoral Thesis (2006).
[11] Son SY. The Effects of XCO and Lumbar Stabilization Exercise on Trunk Muscle Activity, Back Strength, and Pain in the Patients with Chronic Low Back Pain. Nambu University, Master's Thesis (2015).
[31] Yu HJ. Effect of 6-week Scapula Stabilization Exercise on Scapula Position and Range of Motion after Breast Cancer Surgery. Hanseo University, Master's Thesis (2020).

6.3. Additional references

[1] https://www.cancer.go.kr/ (2021).

7. Appendix

7.1. Author's contribution

	Initial name	Contribution
Lead Author	ML	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑
Corresponding Author*	SP	-Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	MSP	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

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Causes and Implications of Type I Myofiber Grouping in Parkinson's Disease: A Brief Scoping Review

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Abstract

Purpose: *The purpose of this study was to review the alterations in muscle fibers in Parkinson's disease(PD). The following were our review questions. (1)How has research on type I myofiber grouping in PD developed over time? (2)What kinds of muscles are affected in which patients? (3)What are some possible pathophysiology and mechanisms? Does type I myofiber grouping in PD differ from primary sarcopenia that occurs with aging? (4)What are the clinical implications and possible therapeutic approaches for type I myofiber grouping in PD?.*

Method: *To investigate the questions, we used combinations of keywords such as "Parkinson", "skeletal muscle", "myofiber type", "fast twitch", "slow twitch", "myofiber grouping", and "motor unit" in PubMed and Google Scholar. Articles on PD patients and normal elderlies that dealt with type I myofiber grouping and motor unit alterations were included. References in the included articles were also considered.*

Results: *Research over the past five decades has identified various motor abnormalities and myofiber alterations in PD patients, including the hypertrophy of slow-twitch type I myofibers and atrophy of fast-twitch type II myofibers across different muscles. One important finding is that Type I myofiber grouping, which is common in aging, is more severe in PD, which could be due to the selective activation of low-threshold motor units and could be also linked to abnormal alpha-synuclein aggregation, a factor associated with PD.*

Conclusion: *Research suggests that type I myofiber grouping in muscles, not just dopaminergic cell damage in the substantia nigra, could influence motor symptoms of PD, indicating that alternative treatments beyond dopaminergic drugs, such as high-intensity exercise, might be beneficial. However, given the limitations in these studies, such as small participant numbers and the complexity of PD pathophysiology, future research is needed to fully understand the phenomena in different PD subtypes and to develop more effective treatments.*

Keywords: ***Parkinson's Disease, Neurodegenerative Disease, Skeletal Muscle, Type I Myofiber Grouping, Scoping Review***

1. Introduction

Parkinson's disease(PD) is the fastest-growing and second-most common degenerative brain disease, characterized by gradual degenerative changes in the central nervous system[1], but changes in muscle fibers are less well-known. Edström(1970) was the first to report that the sizes of red and white muscle fibers are altered in PD patients[2]. Edström discovered that the group of white muscle fibers was atrophied and the group of red muscle fibers was either unchanged or hypertrophied through muscle biopsy. According to the author, the change may be caused by decreased muscular strength and increased rigidity. In comparison to the damage to the nervous system in PD patients, the topic has received little attention since then, but ongoing studies are still being reported.

PD patients develop motor symptoms such as bradykinesia, rigidity, tremor, and postural instability, and non-motor symptoms such as constipation, depression, anxiety, insomnia, fatigue, pain, urinary symptoms, and autonomic dysfunction as the disease progresses[3]. Dopaminergic drugs such as levodopa can effectively help PD patients manage their symptoms. However, more than half of PD patients experience a wearing-off phenomenon 2 to 5 years after starting dopaminergic medication[4]. In a Korean study, about half of the patients who took dopaminergic drugs for more than 12 months complained of the wearing-off phenomenon, and the patients' Unified Parkinson's Disease Rating Scale(UPDRS) Part 3 score, a clinical scale of motor signs of PD, deteriorated significantly in the off state(8 out of a total score of 108 points)[5]. In the case of PD, a standard disease-modifying treatment has not yet been established. Therefore, there is currently an unmet need for methods and techniques for managing and treating the disease[6].

Meanwhile, recent research suggests that, when applied over time, various types of exercise may have disease-modifying effects on P[7]. It has been well established through studies using several animal models that exercise has a neuroprotective effect, and studies using PD animal models have also revealed that exercise exhibits a dopamine neuroprotective effect. The reason for this effect is not fully understood, but researchers believe that exercise reduces the vulnerability of neurons by expressing neurotrophic factors[8]. On the other hand, there haven't been many studies on the effect of exercise on the altered muscle fibers of PD patients. At this point, a recent study suggests that resistance exercise can reverse type I myofiber grouping in PD patients. It is anticipated that additional research will be conducted in the future[9]. Therefore, in this review, we aimed to thoroughly examine the changes in muscle fibers in PD and speculate on the clinical implications and potential therapeutic approaches to the phenomenon.

2. Methods

2.1. Review questions

i. How has research on type I myofiber grouping in PD developed over time?

ii. What kinds of muscles are affected in PD patients?

iii. What are some possible pathophysiology and mechanisms? Does type I myofiber grouping in PD differ from primary sarcopenia that occurs with aging?

iv. What are the clinical implications and possible therapeutic approaches for type I myofiber grouping in PD?

2.2. Study selection

In this review, we included studies involving patients with PD. To investigate the questions, we used combinations of keywords such as “Parkinson”, “skeletal muscle”, “myofiber type”, “fast twitch”, “slow twitch”, “myofiber grouping”, and “motor unit” in PubMed and Google Scholar. Articles on PD patients and normal elderlies that dealt with type I myofiber grouping and motor unit alterations were included. References in the included articles were also considered.

3. Results and Discussion

3.1. Type I myofiber grouping in parkinson’s disease

Edström(1970) first reported that in PD patients, muscle fibers with a high concentration of myofibrillar ATPase(fast-twitch, generally known as ‘white’, type II fibers) were atrophied while fibers with a low concentration of myofibrillar ATPase(slow-twitch, generally known as ‘red’, type I fibers) were either unchanged or hypertrophied, as discovered through a muscle biopsy. The author suggests that the change may be due to muscular weakness and hypertonia in PD patients[2]. Years later, Sica and colleagues(1973) observed a decrease in the number of functional motor units and abnormal enlargement of the remaining motor units in the extensor digitorum brevis muscle of PD patients. The authors associated these phenomena with these individuals' loss and dysfunction of alpha-motor neurons[10]. Meanwhile, Grimby and Hannerz(1974) observed that PD patients experiencing bradykinesia demonstrate a reduced capacity to transition between tonic and phasic motor unit recruitment, and the reverse as well. The authors propose that passive stretching of the muscle could potentially normalize voluntary activity, while relieving the muscle load may rectify the abnormal termination of voluntary actions in PD patients[11]. In 1979, Edström and colleagues additionally found that in PD patients, type I and type IIA fibers showed normal levels of sulfur and phosphorus. However, type IIB fibers(usually referred to as Type IIX fibers in more recent literature), particularly the atrophic ones, displayed a marked reduction in sulfur content and an increase in phosphorus content. The authors attributed the findings to the disuse of high activation threshold fast-twitch type IIB motor units[12].

During the 1980s and 1990s, the idea again slowly developed. Dietz et al.(1981) observed that PD patients frequently exhibited synchronized bursts of electromyography in the leg muscles and increased muscle tone. The authors suggested that these observations may be partially attributed to the increase in slow muscle fibers in PD patients. These fibers, given their unique contractile properties, displayed a heightened resistance to stretching[13]. In 1991, Pedersen and colleagues found that in PD patients, the time taken for the adductor pollicis muscle to reach half tetanus contraction was notably shorter compared to a control group, a result unaffected by medication status. Moreover, the speed at which muscles relaxed in PD patients was notably increased compared to the normal control group, possibly indicating an elevated muscle metabolism due to higher muscle tone. The authors suggested that the shortened muscle contraction time and increased muscle relaxation rate could be factors contributing to muscle stiffness in PD patients[14]. In 1996, Rossi et al. indirectly evaluated PD patients’ muscle modification using surface electromyography and muscle biopsy. The researchers discovered that in PD patients, there was a tendency for type I fibers in the tibialis anterior muscle to hypertrophy. This was also associated with a reduced rate of conduction velocity and changes in median frequency during stimulated contraction of the same muscle in these patients[15].

In the 2000s, Nuyens et al.(2000) found that PD patients exhibited a decrease in resistive torque during repetitive tasks when compared to healthy individuals. The researchers hypothesized that this finding could be partially attributed to a reduction in voluntary muscle strength and a shift in muscle fiber types towards low-threshold tonic fibers due to hypertonia, coupled with the selective disuse of high-threshold phasic motor units[16]. In 2002, Inkster and colleagues conducted a study comparing lower leg strength and the capacity to stand up from a chair between PD patients and control subjects. Despite the PD patients in this study having mild PD and maintaining activity levels similar to the control group, the authors discovered that these PD patients exhibited lower extensor torques in their hip and knee[17]. Building on this, Pääsuke et al.(2004) also identified leg extensor muscle weakness in PD patients, a condition that was found to be associated with difficulties in rising from a chair. The authors underlined the multifaceted nature of muscle weakness in PD patients, pointing to abnormal motor unit discharge patterns and peripheral alterations in muscle fibers as potential contributing factors[18]. In 2004, another group of researchers explored if the muscle weakness observed in PD patients was a result of reduced agonist activation, the engagement of a pathological oscillator, or a combination of both. The researchers suggested that the high occurrence of type I fibers, which exhibit lower discharge frequency, in the muscles of PD patients might have influenced their findings[19]. In 2007, Mak et al. conducted a quantitative analysis of trunk rigidity in PD patients. They proposed that in PD patients, the resistance of trunk muscle tone increased more noticeably with an increase in passive movement speed compared to the control group. Furthermore, the data was more consistent in PD patients than in the control group. The authors speculated that this could be attributed to alterations in the trunk muscles of PD patients[20].

In the decade of the 2010s, Mu et al.(2012) revealed that PD patients experiencing dysphagia showed signs of fiber atrophy, fiber type grouping, and a transition from fast to slow myosin heavy chain in their pharyngeal constrictor and cricopharyngeus muscles[21]. This research group also identified a link between these phenomena and damage to the peripheral motor nerves, such as nerve X, the pharyngeal branch of nerve X, intramuscular nerve branches, and axon terminals in the neuromuscular junctions. This damage was assessed by examining the histopathological marker of alpha-synuclein aggregates[22]. Kelly et al.(2014) investigated the muscle tissue phenotype and discovered that PD patients had a larger cross-sectional area of type I myofibers and greater type II myofiber size heterogeneity than non-PD controls[23]. Nishikawa and colleagues(2017) explored the spatial distribution pattern of electromyography during continuous contraction of the vastus lateralis muscle in both healthy individuals and those with PD. The investigators found that in PD patients, the variations and alterations in the activation pattern were less pronounced than in healthy individuals. The researchers theorized that there could be irregularities in the descending commands originating from the basal ganglia and directed to the motor neurons in PD patients, which may lead to aberrations in the recruitment strategies of motor units. Additionally, the researchers suggested the potential for fiber type grouping in PD patients, which could further impact changes in the amplitude distribution of spatial electromyography[24]. Krumpolec and colleagues(2017) examined the impact of aerobic-strength workouts on total body metabolism and the properties of skeletal muscles in PD patients and age-matched control subjects. The researchers found that the vastus lateralis muscle in PD patients showed hypertrophy of type II fibers after endurance training. Exercise could also reduce the type I/type II fiber ratio in both the control group and PD patients, according to the study[25]. Kelly et al.(2018) likewise studied the impact of resistance training on the remodeling of motor units of the vastus lateralis muscle in PD patients, as well as young and older adults without PD. PD patients showed greater motor unit remodeling than what is typically seen in normal aging, and resistance training could potentially reverse myosin heavy chain expression in some of the grouped type I myofibers[9].

In the 2020s, Lavin et al.(2020) studied the transcriptional networks in skeletal muscle that are associated with Type I myofiber grouping in PD patients, as well as in older adults who were matched for both age and sex, and young adults who were matched for sex. The researchers identified co-expression networks linked to phenotypes that were pathologically increased in PD muscle tissue. The networks were associated with the size of type I myofiber groups and another network was related to the percentage of type I myofibers found within these groups. These networks were related to various biological processes, such as neurotransmission, neural development, cell survival, regulation of the cell cycle, inflammation, and energy metabolism[26]. Nishikawa et al.(2020) examined the motor unit behavior in female PD patients using surface electromyography. The authors found out that compared to control subjects, PD patients exhibited laterality of motor unit activation in their legs. Furthermore, PD patients demonstrated reduced muscle strength and irregular motor unit activity, which included increased rates of motor unit firing and an abnormal relationship between the average motor unit firing rate and motor unit threshold[27]. The same group of researchers(2022) compared the vastus lateralis muscle activity in female PD patients and the healthy age-matched female controls. In comparison to the control subjects, those with PD exhibited considerably higher entropy and reduced heterogeneity in the electromyography signals from the more impacted side of the lower limbs. Furthermore, this asymmetry in motor patterns continued to be present even when the patients were on dopaminergic medications[28]. On another note, Ginanneschi and colleagues(2021) studied alterations in the excitability of the corticomotor pathway following upper-limb exercise in patients with PD. They found that the score for Part 3 of the UPDRS improved after two months of training, and this improvement was linked to a higher plateau of the post-training input-output curve obtained through transcranial magnetic stimulation. The authors proposed that this outcome suggests that exercise training might rehabilitate the recruitment and firing rate of large motor units, specifically Type II motor units, which are capable of fast and powerful movements[29].

3.2. Type I myofiber grouping in various muscles of PD patients

Research spanning several decades has significantly enhanced our understanding of the type I myofiber grouping in PD patients. Early studies in the 1970s detected atrophy in fast-twitch muscle fibers and irregularities in shifting between motor unit types[1][9][10][11]. In the following decades of the 1980s and 1990s, observations included synchronized bursts of electromyography in leg muscles, faster muscle contraction and relaxation rates, and changes detectable through electromyography and biopsies. These phenomena were thought to be related to modifications in muscle fibers and a preference for low-threshold tonic fibers[12][13][14]. Research in the 2000s also highlighted decreased resistive torque, weakened leg muscles, and trunk rigidity alterations in PD patients, suggesting abnormal motor unit discharge and muscle fiber changes[15][16][17][18][19]. During the 2010s, studies by Mu and colleagues[20][21] underscored the presence of dysphagia in PD patients, indicating signs of fiber atrophy, fiber type grouping, and a shift in myosin heavy chain within their pharyngeal muscles. Additionally, other researchers during this decade observed alterations in muscle activation, and the possible advantages of resistance training[9][23][24][25]. In the 2020s, research delved into transcriptional networks in skeletal muscles, motor unit behavior, and the impact of exercise on large motor units. Findings highlighted asymmetric motor unit activation, irregular motor unit activity, and persisting asymmetry in motor patterns, even when under medication[26][27][28][29]. Over the years, research has revealed a complex interaction between neuronal and muscular factors in the pathology of PD patients. We can construct the following overview by categorizing these studies according to specific muscles as shown in <Table 1>.

Table 1. The effect of type I myofiber grouping on specific muscles in parkinson's disease patients.

Fiber type / Muscle type	Type I myofiber	Type II myofiber
Biceps brachii muscles	Hypertrophy(in patients with marked rigidity) or atrophy(in patients who were affected by akinesia and had minor rigidity)[2]	Atrophy[2]; a significant decrease in sulfur in atrophied type IIB fiber[12]
Quadriceps femoris muscles	Type I myofiber grouping[9][23][24]; increased type I myofiber group size, cross-sectional area, and motor unit activation[9][23]	Atrophy(type IIB fibers), & decrease sulfur concentration in atrophied type IIB fibers[12]; heterogeneous type II myofiber size[9][23]
Tibialis anterior muscles	Hypertrophy, which was associated with smaller conduction velocity, and median frequency of the power spectrum(non-invasive surface electromyography)[15]	Atrophy in some cases[15]
Pharyngeal muscles	Atrophy, type I myofiber grouping in the pharyngeal constrictor and cricopharyngeus muscles, associated with dysphagia[21]	Decrease in the number, and a transition from a fast to slow myosin heavy chain in the pharyngeal constrictor and cricopharyngeus muscles[21]
Paraspinal muscles	Hypertrophy[30]	Loss[30]

3.2.1. Biceps brachii muscles

Edström in the 1970s described that in the case of the biceps brachii muscle, there was a tendency for type II fibers to atrophy. For type I fibers, they appeared at normal size or even showed a tendency for hypertrophy in patients with marked rigidity. Conversely, atrophy was also observed in patients who were predominantly affected by akinesia and had minor rigidity[2]. In 1979, Edström et al. conducted fiber type analysis of the muscle based on stainability for alkali and acid-stable ATPase and measured relative concentrations of phosphorus, sulfur, chlorine, and potassium. The authors discovered type IIB fiber atrophy and a significant decrease in sulfur in atrophied type IIB muscles in PD patients[12].

3.2.2. Extensor digitorum brevis muscles

Sica et al.(1973) discovered the functional motor unit loss and abnormally large remaining motor units in the extensor digitorum brevis muscle of PD patients. In some of the PD patients, the researchers discovered prolonged terminal motor latencies in the deep peroneal nerve and a decreased response of the extensor digitorum brevis muscle[10].

3.2.3. Quadriceps femoris muscles

Edström et al.(1979) also investigated the fiber type of the quadriceps femoris muscle. The researchers discovered that, like the biceps brachii muscle, type IIB fibers were atrophied in PD patients, and that the sulfur concentration in atrophied type IIB fibers of the quadriceps femoris muscle was decreased[12]. Later, Nishikawa et al.(2017) applied spatial electromyography and discovered that alterations and variations in the vastus lateralis muscle activation patterns were not as distinct in individuals with PD as in healthy subjects. This suggests that abnormal motor unit recruitment strategies may be in effect, along with fiber type grouping in the muscles of PD patients[24]. Kelly et al.(2014 & 2018) discovered that type I myofiber group size and cross-sectional area, as well as motor unit activation were increased in PD patients when compared to older and young adults. The researchers also discovered that type II myofiber size was more heterogeneous in PD patients than in non-PD controls[9][23].

3.2.4. Adductor pollicis muscles

Pedersen et al.(1991) discovered that the contraction time and relaxation rate were decreased and increased in PD patients, respectively. Because both muscle tone and metabolism are generally elevated in PD patients, the authors hypothesized that the phenomenon could have been caused by muscle stiffness. Because Parkinsonian medication did not affect muscle contraction time or force output, the authors hypothesized that secondary changes in PD patients' muscles could influence muscle contraction characteristics in the long run[14].

3.2.5. Tibialis anterior muscles

Using muscle biopsy, Rossi et al. discovered a tendency for type I fiber hypertrophy and type II fiber atrophy in the tibialis anterior muscle of PD patients. The conduction velocity and median frequency of the power spectrum of the tibialis anterior muscle were smaller in PD patients with type I fiber hypertrophy, according to non-invasive surface electromyography[15].

3.2.6. Pharyngeal muscles

Mu et al.(2012) revealed that pharyngeal constrictor and cricopharyngeus muscles in PD patients with dysphagia showed signs of fiber atrophy, especially type I fibers, fiber type grouping, and a transition from fast to slow myosin heavy chain[21]. The same group of researchers also discovered a link between these phenomena and damage to peripheral motor nerves such as nerve X, the pharyngeal branch of nerve X, intramuscular nerve branches, and axon terminals in neuromuscular junctions. The histopathological marker of alpha-synuclein aggregates[22] was used to assess this peripheral nerve damage.

3.2.7. Paraspinal muscles

Wrede et al.(2012) biopsied the paraspinal muscles of PD patients with camptocormia and discovered hypertrophied type 1 fiber and loss of type 2 fibers, structural defects in the disorganized fibers, and loss of oxidative enzyme activity and phosphatase reactivity. The author hypothesized that such changes in the trunk muscles could result in camptocormia and diminished ability to maintain the trunk's upright posture[30].

To sum up, the grouping of type I muscle fibers in PD seems to be muscle-specific and is associated with the disease's duration, severity, and particular symptoms such as muscle weakness and rigidity. While there are instances where atrophy of type I muscle fibers is reported, a trend toward hypertrophy is often observed. Although hypertrophy of type I muscle fibers can sometimes be found in ungrouped fibers, it is more commonly seen in grouped fibers[21][30].

In certain instances, like in the pharyngeal muscles, type I muscle fiber grouping can be observed, but instead of hypertrophy, the muscle fibers may reduce in size[21]. Conversely, type II muscle fibers often show a tendency to atrophy. Exercise training has the potential to alter both the composition and size of type I and II muscle fibers. Overall, the proportion of type I myofibers increases while the proportion of type II myofibers decreases. These findings are attributed to motor unit denervation-reinnervation[2][7][9][15][23].

3.3. Postulated pathophysiology and mechanisms

Type I myofiber grouping is a common aging phenomenon caused by denervation-reinnervation of muscle fibers, but the degree of such muscle fiber modification is reported to be more severe in PD[9][31]. The following hypotheses have been proposed as the cause of muscle fiber modification in PD patients. First, individuals with PD often selectively engage low-threshold, tonic motor units, likely due to rigidity or decreased motor capability, and tend to keep high-threshold motor units less active[21][31][32][33]. Furthermore, a decrease in activity in PD patients may result in atrophy, particularly in specific muscles due to muscle fiber disuse. As a result, muscle fibers that are not used may atrophy, while remaining muscle fibers may undergo compensatory hypertrophy[21][31][34][35].

Next, according to Mu et al., Type I myofiber grouping appears to be associated with abnormal alpha-synuclein aggregation[22]. Alpha-synuclein is a presynaptic neuronal protein that is genetically and neuropathologically linked to PD. In PD patients, alpha-synucleinopathy is mostly studied in conjunction with damage to the enteric and central nervous systems[36]. However, the findings suggest that alpha-synucleinopathy-related peripheral nerve damage may be linked to motor unit remodeling in PD[21][22], and more research is needed in this area.

Recently, peripheral neuropathy has been identified in PD patients, alongside the simultaneous occurrence of phosphorylated alpha-synuclein accumulations and mitochondrial dysfunction. Multiple research efforts suggest that such peripheral nerve impairment may be an inherent trait of PD, although the exact mechanism is still unclear. The possible mechanisms behind these phenomena have been suggested to include comorbidity of diabetes, mitochondrial dysfunction, oxidative stress, and mutations in the *Parkin* gene[37]. Furthermore, aggregates of alpha-synuclein in the cutaneous nerves are proposed as a potential biomarker for patients with idiopathic PD. In 2014, Donadio and colleagues found that patients with idiopathic PD exhibited phosphorylated alpha-synuclein in their proximal peripheral nerves. This was associated with small-fiber neuropathy and denervation of the leg epidermis. Given that these alterations were not observed in other patients with parkinsonism, the researchers proposed that the presence of phosphorylated alpha-synuclein could serve as a potential biomarker to differentiate idiopathic PD from other forms of parkinsonism[38]. More recently, Corrà et al. noted a correlation between peripheral neuropathy and gait and balance impairments in PD patients[39]. While the direct link between peripheral nerve damage and type I myofiber grouping in PD patients remains unclear, it's noteworthy that these have been recently emphasized as characteristics in PD patients. Therefore, more research is needed to develop personalized treatments based on these findings. Motor unit remodeling caused by denervation-reinnervation of muscle fibers is known to precede functional deterioration of the muscles in PD[9]. Denervated muscle fibers either die or are reinnervated by the branching axons of nearby motor neurons. Motor unit size and number decrease in the latter case, resulting in abnormal groupings of muscle fibers expressing the same myosin heavy chain isoform. As a result, abnormal recruitment of motor units occurs in such grouped muscle fibers[37]. Dual innervation by two separate motor neurons occurs in some aged muscle fibers, particularly in the elderly, which may explain why type I to type II conversion is possible[9]. Furthermore, regardless of exercise or drugs, these skeletal muscle changes tend to occur from an early stage of the disease[33][40]. Muscle atrophy can be observed as early as the initial stages of PD, and PD-related neuropathology can lead to further muscle atrophy and weakness, creating a vicious cycle[41].

Type I myofiber grouping is found not only in PD patients but also in the muscles of the elderly. Grouped type I myofibers exhibit some of the characteristics of type II myofibers, such as recruitment-dependent hypertrophy, low capillary supply, and sarcoendoplasmic reticulum calcium ATPase expression. This implies that type II muscle fibers converted to type I muscle fibers via denervation-reinnervation are not fully converted to type I muscle fibers. Furthermore, type II muscle fibers converted to type I muscle fibers are thought to have a higher potential for hypertrophy than original type I muscle fibers. As a result, these factors may be responsible for the hypertrophy of type I myofibers in muscles where type I myofiber grouping has occurred[40].

The following may explain why the proportion and grouping of type I myofibers increase selectively during muscle denervation-reinnervation. First, while denervation may occur at the same rate for all myofiber types, it is reasonable to assume that preferential reinnervation to type I myofibers occurs because motor units with lower thresholds are recruited first. Furthermore, motor symptoms of PD, which activate motor units with a low threshold and increase skeletal muscle tone, may also facilitate reinnervation into type I myofibers by favoring the maintenance of low-threshold motor units[2][9][42][43]. In a study of gene transcriptional profiling of skeletal muscle samples, the increase in group size and the ratio of type I muscle fibers in PD was found to be related to altered gene expression, and skeletal muscle itself could play an active role in signal transduction to promote muscle fiber survival, nerve redistribution, and remodeling[26].

3.4. Possible therapeutic approaches

Motor symptoms such as bradykinesia, postural instability, and rigidity in PD are typically understood in relation to dopaminergic cell damage in the substantia nigra. However, according to the above-mentioned research findings, type I myofiber grouping in various muscles of PD patients also appears to affect motor symptoms such as rigidity or muscle weakness in the patients. For example, Mu et al. discovered that type I fiber grouping in pharyngeal muscles of PD patients was associated with dysphagia. Dysphagia is a symptom of PD that doesn't respond well to drug treatment[21]. Other researchers, including Pedersen et al.(1991) and Nishikawa et al.(2022), also found PD-related motor patterns that appear to be related to type I myofiber grouping that was unaffected by medication status[14][28]. These findings indicate that dopaminergic drugs cannot effectively treat PD symptoms stemming from muscle fiber modifications. It is therefore critical to develop a variety of alternative disease-modifying interventions[21].

According to Kelly et al.[9][23], high-intensity exercise, such as resistance training, can improve the size of muscles, mitochondrial function, and physical fitness in PD patients. The authors discovered that after high-intensity exercise training, type II myofibers in their study switched from more fatigable IIX to less fatigable IIA. In addition, there was hypertrophy in both type I and II fibers, and mitochondrial complex activity in the muscle fibers increased[23]. Resistance training may also help to stabilize neuromuscular junction and motor unit activity. Resistance training was found to reverse a portion of grouped type I myofibers in PD patients with the most advanced type I myofiber grouping by reversing their myosin heavy chain expression[9].

These findings suggest that some grouped type I myofibers in PD patients can be converted to type II myofibers via strength training or high-intensity exercise. However, there is a lack of research on how much exercise is most effective in grouped muscle fibers in PD patients. Furthermore, many type II muscle fibers in PD patients have already been grouped and converted to type I myofibers. It is also important to consider the possibility that it will be difficult for all the converted muscle fibers to recover to their original state. As a result, a variety of exercises that can activate both the patients' remaining types I and II myofibers must be developed to ensure that the remaining motor units are not further damaged and are well maintained. Energy metabolism issues or neuroinflammation, according to Lavin et al.[20], can also affect type I myofiber grouping. As a result, it can be inferred that restoring impaired circadian rhythm and energy metabolism, as well as improving PD patients' metabolic state may be beneficial in treatment.

Meanwhile, therapies such as bee venom acupuncture, known for its neuroprotective effects, could also be explored as options for PD patients to mitigate peripheral nerve damage. Studies by Cho and colleagues in 2012 and 2018 showed significant enhancements in the UPDRS score for PD patients who underwent bee venom acupuncture treatment[44][45]. While continuous exposure to bee venom may not halt neurodegeneration sufficiently to prevent the manifestation of PD[46], it might exhibit local neuroprotective effects on the peripheral nerves of these patients. Several animal-based studies have demonstrated that bee venom possesses a neuroprotective effect against peripheral neuropathy. Research by Baher & Abo-Zeid showed that administering bee venom during early stages served a neuroprotective role against the advancement of diabetic neuropathy and could also reduce blood glucose levels in a rat model of diabetes[47]. Er-Rouassi et al.(2023) showed that injections of bee venom could promote the recovery of section-sutured facial nerves. Furthermore, these injections also enhanced functional restoration and reinnervation, as seen in the improvements in whisker movement and normalization of nasal deviation[48]. These findings indicate that bee venom exhibits a local neuroprotective effect. When applied locally, it could potentially impede further type I myofiber grouping in individuals with PD. However, further research is needed to fully explore this potential.

4. Conclusion

Over the last five decades, research on PD patients has revealed a variety of motor abnormalities and muscle changes. Edström first reported selective changes in the sizes of red and white muscles in PD patients in the 1970s. Since then, researchers have been investigating atrophy in fast-twitch muscle fibers, inconsistencies in shifting motor unit types, synchronized bursts of electromyography, decreased resistive torque, weakened leg muscles, and changes in trunk rigidity. It appears that different muscles in the trunk, as well as the upper and lower extremities, are all affected in PD, with the general tendency being hypertrophy of slow-twitch type I myofibers and atrophy of fast-twitch type II myofibers.

Type I myofiber grouping, a common aging phenomenon, is markedly worse in PD, possibly due to selective activation of low-threshold, tonic motor units. This remodeling, which is caused by denervation-reinnervation, occurs before functional muscle deterioration in PD and results in abnormal recruitment of motor units in grouped fibers. This grouping is also associated with abnormal alpha-synuclein aggregation, a neuronal protein linked to PD, suggesting that alpha-synucleinopathy-related peripheral nerve damage could be linked to motor unit remodeling.

While motor symptoms of PD are typically attributed to dopaminergic cell damage in the substantia nigra, research suggests that type I myofiber grouping in various muscles could also influence symptoms such as rigidity or muscle weakness. Symptoms such as dysphagia, which do not respond well to drug treatment, have been associated with type I fiber grouping. Consequently, dopaminergic drugs may not effectively treat PD symptoms arising from muscle fiber changes, highlighting the need for alternative interventions. High-intensity exercise like resistance training, has been found to induce beneficial changes in muscle fibers, potentially converting some grouped type I myofibers back to type II in PD patients. However, challenges remain, including determining the most effective exercise volume and addressing metabolic issues and neuroinflammation which can also affect type I myofiber grouping.

Meanwhile, according to some studies, the aggregation of alpha-synuclein and peripheral nerve damage have been linked to type I myofiber grouping in PD patients. Moreover, peripheral nerve damage has been recently associated with idiopathic PD. The relationship between the degree of peripheral nerve damage and type I myofiber grouping has not been thoroughly explored yet. Therefore, additional research is needed to understand this potential correlation. Bee venom acupuncture, known for its neuroprotective properties, might also be a potential treatment for peripheral nerve damage in idiopathic PD patients. This could potentially prevent type I myofiber grouping resulting from peripheral nerve damage in these patients, particularly if applied in the early stages.

The studies included in this paper have the following limitations. First, a lot of difficult work was required in studies that performed muscle biopsies on PD patients, typed the myofiber phenotype, and thoroughly evaluated the patient's muscle-specific motor function. As a result, the number of subjects per study was typically limited to around ten people. As a result, the consistency of the results may have weakened from study to study. Furthermore, the pathophysiology of PD is heterogeneous and complex. There is a lack of understanding regarding how myofiber grouping manifests in different subtypes of PD. As a result, more research in this field will be required in the future to develop disease-modifying treatments for PD patients.

5. References

5.1. Journal articles

[1] Dorsey ER & Bloem BR. The Parkinson Pandemic: A Call to Action. *JAMA Neurology*, 75(1), 9-10 (2018).

[2] Edström L. Selective Changes in the Sizes of Red and White Muscle Fibres in Upper Motor Lesions and Parkinsonism. *Journal of the Neurological Sciences*, 11(6), 537-550 (1970).

[3] Poewe W & Seppi K & Tanner CM & Halliday GM & Brundin P & Volkmann J & Schrag AE & Lang AE. Parkinson Disease. *Nature Reviews Disease Primers*, 3(1), 1-21 (2017).

[4] Chou KL & Stacy M & Simuni T & Miyasaki J & Oertel WH & Sethi K & Fernandez HH & Stocchi F. The Spectrum of Off in Parkinson's Disease: What Have We Learned Over 40 Years?. *Parkinsonism & Related Disorders*, 51, 9-16 (2018).

[5] Seo JH & Cheon SM & Kim JW. The Correlation of On and Off Status with Clinical Characteristics in Patients with Parkinson's Disease. *Journal of Movement Disorders*, 1(2), 65-70 (2008).

[6] Lang AE & Espay AJ. Disease Modification in Parkinson's Disease: Current Approaches, Challenges, and Future Considerations. *Movement Disorders*, 33(5), 660-677 (2018).

[7] Mak MK & Wong-yu IS & Shen X & Chung CL. Long-term Effects of Exercise and Physical Therapy in People with Parkinson Disease. *Nature Reviews Neurology*, 13(11), 689-703 (2017).

[8] Zigmond MJ & Smeyne RJ. Exercise: Is It a Neuroprotective and If So, How Does It Work?. *Parkinsonism & Related Disorders*, 20, 123-127 (2014).
[9] Kelly NA & Hammond KG & Bickel CS & Windham ST & Tuggle SC & Bamman MM. Effects of Aging and Parkinson's Disease on Motor Unit Remodeling: Influence of Resistance Exercise Training. *Journal of Applied Physiology*, 124(4), 888-898 (2018).
[10] Sica RE & Herskovits E & Aguilera N & Poch G. An Electrophysiological Investigation of Skeletal Muscle in Parkinson's Disease. *Journal of the Neurological Sciences*, 18(4), 411-420 (1973).
[11] Grimby L & Hannerz J. Disturbances in the Voluntary Recruitment Order of Anterior Tibial Motor Units in Bradykinesia of Parkinsonism. *Journal of Neurology, Neurosurgery & Psychiatry*, 37(1), 47-54 (1974).
[12] Edström L & Gremski W & Wróblewski R. Sulphur and Phosphorus Content in Relation to Fibre Composition and Atrophy of Skeletal Muscle in Patients with Parkinson's Disease. *Journal of the Neurological Sciences*, 41(3), 311-323 (1979).
[13] Dietz V & Quintern J & Berger W. Electrophysiological Studies of Gait in Spasticity and Rigidity. Evidence That Altered Mechanical Properties of Muscle Contribute to Hypertonia. *Brain: A Journal of Neurology*, 104(3), 431-449 (1981).
[14] Pedersen SW & Bäckman E & Öberg B. Characteristics of Tetanic Muscle Contraction in Parkinson Patients. *Acta Neurologica Scandinavica*, 84(3), 250-255 (1991).
[15] Rossi B & Siciliano G & Carboncini MC & Manca ML & Massetani R & Viacava P & Muratorio A. Muscle Modifications in Parkinson's Disease: Myoelectric Manifestations. *Electroencephalography and Clinical Neurophysiology/Electromyography and Motor Control*, 101(3), 211-218 (1996).
[16] Nuyens G & De Weerdt W & Dom R & Nieuwboer A & Spaepen A. Torque Variations during Repeated Passive Isokinetic Movements of the Knee in Subjects with Parkinson's Disease and Healthy Control Subjects. *Parkinsonism & Related Disorders*, 6(2), 87-93 (2000).
[17] Inkster LM & Eng JJ & MacIntyre DL & Stoessl AJ. Leg Muscle Strength Is Reduced in Parkinson's Disease and Relates to the Ability to Rise From a Chair. *Movement Disorders*, 18(2), 157-162 (2003).
[18] Pääsuke M & Ereline J & Gapeyeva H & Joost K & Mõttus K & Taba P. Leg-extension Strength and Chair-rise Performance in Elderly Women with Parkinson's Disease. *Journal of Aging and Physical Activity*, 12(4), 511-524 (2004).
[19] Strambi SK & Rossi B & De Michele G & Sello S. Effect of Medication in Parkinson's Disease: A Wavelet Analysis of Emg Signals. *Medical Engineering & Physics*, 26(4), 279-290 (2004).
[20] Mak MK & Wong EC & Hui-chan CW. Quantitative Measurement of Trunk Rigidity in Parkinsonian Patients. *Journal of Neurology*, 254, 202-209 (2007).
[21] Mu L & Sobotka S & Chen J & Su H & Sanders I & Adler CH & Shill HA & Caviness JN & Samanta JE & Beach TG & Arizona Parkinson's Disease Consortium. Altered Pharyngeal Muscles in Parkinson Disease. *Journal of Neuropathology & Experimental Neurology*, 71(6), 520-530 (2012).
[22] Mu L & Sobotka S & Chen J & Su H & Sanders I & Adler CH & Shill HA & Caviness JN & Samanta JE & Beach TG & Arizona Parkinson's Disease Consortium. Alpha-synuclein Pathology and Axonal Degeneration of the Peripheral Motor Nerves Innervating Pharyngeal Muscles in Parkinson Disease. *Journal of Neuropathology & Experimental Neurology*, 72(2), 119-129 (2013).
[23] Kelly NA & Ford MP & Standaert DG & Watts RL & Bickel CS & Moellering DR & Tuggle SC & Williams JY & Lieb L & Windham ST & Bamman MM. Novel, High-intensity Exercise Prescription Improves Muscle Mass, Mitochondrial Function, and Physical Capacity in Individuals with Parkinson's Disease. *Journal of Applied Physiology*, 116, 582-592 (2014).
[24] Nishikawa Y & Watanabe K & Takahashi T & Orita N & Kimura H & Matsumoto M & Maruyama H. Spatial Electromyography Distribution Pattern of the Vastus Lateralis Muscle during Ramp up Contractions in Parkinson's Disease Patients. *Journal of Electromyography and Kinesiology*, 37, 125-131 (2017).

[25] Krumpolec P & Vallova S & Slobodova L & Tirpakova V & Vajda M & Schon M & Klepochova R & Janakova Z & Straka I & Sutovsky S & Turcani P. Aerobic-strength Exercise Improves Metabolism and Clinical State in Parkinson's Disease Patients. *Frontiers in Neurology*, 8, 698-698 (2017).
[26] Lavin KM & Sealfon SC & McDonald ML & Roberts BM & Wilk K & Nair VD & Ge Y & Lakshman Kumar P & Windham ST & Bamman MM. Skeletal Muscle Transcriptional Networks Linked to Type I Myofiber Grouping in Parkinson's Disease. *Journal of Applied Physiology*, 128(2), 229-240 (2020).
[27] Nishikawa Y & Watanabe K & Holobar A & Maeda N & Maruyama H & Tanaka S. Identification of the Laterality of Motor Unit Behavior in Female Patients with Parkinson's Disease using High-density Surface Electromyography. *European Journal of Neuroscience*, 53(6), 1938-1949 (2021).
[28] Nishikawa Y & Watanabe K & Takahashi T & Maeda N & Maruyama H & Tanaka S & Hyngstrom A. Laterality of the Activation of the Vastus Lateralis Muscle in Females with Parkinson's Disease during the Medication State Compared with Healthy Controls. *Journal of Integrative Neuroscience*, 21(1), 1-8 (2022).
[29] Ginanneschi F & Messa LV & Battisti C & Rossi A. Changes in Corticomotor Pathway Excitability after Exercise Training in Parkinson's Disease. *Neurological Sciences*, 1, 1-7 (2021).
[30] Wrede A & Margraf NG & Goebel HH & Deuschl G & Schulz-Schaeffer WJ. Myofibrillar Disorganization Characterizes Myopathy of Camptocormia in Parkinson's Disease. *Acta Neuropathologica*, 123, 419-432 (2012).
[31] Dalise S & Azzollini V & Chisari C. Brain and Muscle: How Central Nervous System Disorders Can Modify the Skeletal Muscle. *Diagnostics*, 10(12), 1047-1047 (2020).
[32] Jordan N & Sagar HJ & Cooper JA. A Component Analysis of the Generation and Release of Isometric Force in Parkinson's Disease. *Journal of Neurology, Neurosurgery & Psychiatry*, 55(7), 572-576 (1992).
[33] Wierzbicka MM & Wiegner AW & Logigian EL & Young RR. Abnormal Most-rapid Isometric Contractions in Patients with Parkinson's Disease. *Journal of Neurology, Neurosurgery & Psychiatry*, 54(3), 210-216 (1991).
[34] Karpati G & Engel WK. Correlative Histochemical Study of Skeletal Muscle after Suprasegmental Denervation, Peripheral Nerve Section, and Skeletal Fixation. *Neurology*, 18(7), 681-692 (1968).
[35] Hainaut K & Duchateau J. Muscle Fatigue, Effects of Training and Disuse. *Muscle & Nerve*, 12(8), 660-669 (1989).
[36] Stefanis L. α-Synuclein in Parkinson's Disease. *Cold Spring Harbor Perspectives in Medicine*, n009399, 1-24 (2012).
[37] Paul DA & Qureshi AR & Rana AQ. Peripheral Neuropathy in Parkinson's Disease. *Neurological Sciences*, 41, 2691-2701 (2020).
[38] Donadio V & Incensi A & Leta V & Giannoccaro MP & Scaglione C & Martinelli P & Capellari S & Avoni P & Baruzzi A & Liguori R. Skin Nerve α-Synuclein Deposits: A Biomarker for Idiopathic Parkinson Disease. *Neurology*, 82(15), 1362-1369 (2014).
[39] Corrà MF & Vila-Chã N & Sardoeira A & Hansen C & Sousa AP & Reis I & Sambayeta F & Damásio J & Calejo M & Schicketmueller A & Laranjinha I. Peripheral Neuropathy in Parkinson's Disease: Prevalence and Functional Impact on Gait and Balance. *Brain*, 146(1), 225-236 (2023).
[40] Kelly NA & Hammond KG & Stec MJ & Bickel CS & Windham ST & Tuggle SC & Bamman MM. Quantification and Characterization of Grouped Type I Myofibers in Human Aging. *Muscle & Nerve*, 57(1), 52-59 (2018).
[41] Saiki S & Hatano T & Fujimaki M & Ishikawa KI & Mori A & Oji Y & Okuzumi A & Fukuhara T & Koinuma T & Imamichi Y & Nagumo M. Decreased Long-chain Acylcarnitines From Insufficient β-oxidation as Potential Early Diagnostic Markers for Parkinson's Disease. *Scientific Reports*, 7(1), 7328-7328 (2017).
[42] Blaauw B & Schiaffino S & Reggiani C. Mechanisms Modulating Skeletal Muscle Phenotype. *Comprehensive Physiology*, 3(4), 1645-1687 (2013).

[43] Lexell J & Downham DY. The Occurrence of Fibre-type Grouping in Healthy Human Muscle: A Quantitative Study of Cross-sections of Whole Vastus Lateralis from Men between 15 and 83 Years. *Acta Neuropathologica*, 81(4), 377-381 (1991).
[44] Cho SY & Shim SR & Rhee HY & Park HJ & Jung WS & Moon SK & Park JM & Ko CN & Cho KH & Park SU. Effectiveness of Acupuncture and Bee Venom Acupuncture in Idiopathic Parkinson's Disease. *Parkinsonism & Related Disorders*, 18(8), 948-952 (2012).
[45] Cho SY & Lee YE & Doo KH & Lee JH & Jung WS & Moon SK & Park JM & Ko CN & Kim H & Rhee HY & Park HJ. Efficacy of Combined Treatment with Acupuncture and Bee Venom Acupuncture as an Adjunctive Treatment for Parkinson's Disease. *The Journal of Alternative and Complementary Medicine*, 24(1), 25-32 (2018).
[46] Klarendić M & Kirbiš M & Mojsovska E & Kavčič M & Sadikov A & Georgiev D & Kojović M. Bee Venom Does Not Reduce the Risk for Parkinson's Disease: Epidemiological Study among Beekeepers. *Movement Disorders*, 37(1), 211-213 (2022).
[47] Baher W & Abo-Zeid AA. The Neuroprotective Effect of Bee Venom Against Diabetic Neuropathy in a Rat Model: Ultrastructure and Morphometric Study. *European Journal of Pharmaceutical and Medical Research*, 4(8), 50-59 (2017).
[48] Er-Rouassi H & Bakour M & Touzani S & Vilas-Boas M & Falcão S & Vidal C & Lyoussi B. Beneficial Effect of Bee Venom and Its Major Components on Facial Nerve Injury Induced in Mice. *Biomolecules*, 13(4), 680-680 (2023).

6. Appendix

6.1. Author's contribution

	Initial name	Contribution
Lead Author	MSP	-Set of concepts ☑ -Design ☑ -Getting results ☑
Co-author	JC	-Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑
Co-author	HY	-Corresponding ☑ -Play a decisive role in modification ☑
Corresponding Author*	SP	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

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Case Study on the Change of Body Composition and Physical Fitness of Female College Students through Six-Week Home Training

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Abstract

Purpose: *The purpose of this study is to investigate the effects of home training(HT) and gym training(GT) on body composition and basic physical fitness in female college students.*

Method: *In this study, 39 female first-year physical education students enrolled in K University in D city were selected as the subjects of the home training group(HT, n=15), gym training group(GT, n=12), and control group(Con, n=12). The subjects were fully informed of the purpose of the study and gave their voluntary consent to participate in the study. Body composition was measured by Weight, Body Mass Index, Percent Body Fat, Body Fat Mass, Lean Body Mass, and Skeletal Muscle Mass. Physical fitness was measured by grip strength, sit-ups, vertical jump, sitting trunk flexion, and standing on one leg with eyes closed. The exercise program consisted of a warm-up, main exercises(upper body, core, and lower body), and a cool-down, with the core exercises being the same for both programs. Data processing for this study was performed using the SPSS 27.0 statistical program to calculate the mean and standard deviation for each measure, and a two-way analysis of variance with repeated measures was performed to examine the effect of each item by group and time of measurement. If the interaction was significant, a paired samples t-test was performed, and a one-way analysis of variance was performed to analyze the difference in the mean of the dependent variable between groups at the same time point. Statistical significance was considered at p<.05 for all measures.*

Results: *The main effects of body composition period were significant(p<.05) for body weight, LBM, and skeletal muscle mass, with no significant group interaction. Post hoc tests of the main effect of time revealed a significant main effect for body weight, but no significant post hoc differences from pre to post for any group. The main effects of physical fitness period were significant(p<.01) for the vertical jump, grip strength(left), grip strength(right), sit-ups, and standing on one leg with eyes closed, but the group interaction was not significant for all items. Post hoc tests of the main effect of time showed that the HT group significantly(p<.05) increased from pre to post in the standing vertical jump, grip strength(left) was significantly(p<.05) lower in the GT group from pre to post, and sit-ups were significantly(p<.01) higher in the HT group from pre to post.*

Conclusion: *Gathering the results above, the home training group showed an increase in sit-ups and vertical jump in place from the pre- to post-training, it is possible to see some effectiveness of the training, but it is difficult to clear conclusions. Therefore, further research is needed to determine the effectiveness of home training.*

Keywords: ***Female College Students, Home Training, Gym Training, Body Composition, Physical Fitness***

1. Introduction

The sudden and disruptive lifestyle changes in recent years have brought about a major shift in the paradigm of health promotion and physical activity. Since the outbreak, there has been a sharp decline in the culture of exercise participation due to emotional, social, and personal reasons, but the desire to move, which is human nature, has created an atmosphere where methods for physical activity and health promotion are being explored and developed differently than before the pandemic[1].

Even before the coronavirus pandemic, modernized societies have seen a decline in physical activity due to the prevalence of sedentary work and automated workplaces, leading to a health problem known as hypokinetic disease[2]. At the center of these changes is the growing popularity of home training, a compound word that combines the words "home" for house and "training" for exercise, and has become a trend for the modern era[3]. With the current trend of increasing utilization and frequency of video sites as well as social network services(SNS), it has grown to become one of the most prominent and accessible health promotion and hobby activities for modern people in the post-COVID-19 era.

Home training refers to exercises that use your own body weight and do not use any specific tools, and it is a Korean expression that refers to exercises that you do on your own at home to maintain your health, lose weight, and get in shape[4][5]. It also saves time and money, which is the biggest advantage of home training, and has become a trendy way to get in shape at home without having to visit an indoor or outdoor sports center. Thanks to the use of electronic devices, social media, and media technology, more and more people are using home training because they can access know-how and various exercise methods through video content without having to communicate directly with professional trainers[6][7]. Accordingly, the demand for home training that can be conveniently performed at home without time and space constraints is increasing, and the related market is growing rapidly. For example, real-time, non-face-to-face exercise programs using the video conferencing platform zoom have recently been reported to be highly preferred, and studies have been published to verify the effectiveness of exercise[8][9].

A review of the literature on face-to-face home training suggests that while it does not have a significant effect on weight loss, regular home training has been reported to have positive improvements in physical self-efficacy and psychological factors associated with depression in obese individuals[10]. In addition, in the field of health and exercise psychology, home training has been shown to improve an individual's objective physical performance, such as athletics or dance, as well as their subjective physical performance[11][12].

In addition to improving these psychological factors, adequate levels of physical activity can help relieve stress and prevent disease, and play an important role in health management, so it can be seen that quality of life and home training are closely related[13][14]. Furthermore, a study on the effects of four weeks of virtual home training on stress, depression, and self-efficacy in adults confirmed the positive effects of home training on stress, depression, and self-efficacy[3][15]. The results confirmed the positive psychological effects of online, non-face-to-face home training for health for people with environmental and social limitations.

The studies discussed above have shown that participation in exercise has a positive impact on self-efficacy and health, and that adequate levels of physical activity can help reduce stress and prevent disease. However, the various benefits of a proper exercise program through home training, which has gained popularity since COVID-19, have not been validated.

Therefore, this study investigated the effects of home training(HT) and gym training(GT) on body composition and basic physical fitness of female college students.

2. Research Method

2.1. Participants

The subjects of this study were first-year female students of physical education enrolled in D City K University, and a total of 39 subjects were selected as home training group(HT, n=15), gym training group(GT, n=12), and control group(Con, n=12). This study was selected as a person who can perform physically and healthily without difficulty, and before entering this experiment, it was conducted after receiving sufficient explanation of the purpose of the study and consent to active participation. The physical characteristics of the research subjects are shown in <Table 1>.

Table 1. Characteristics of the participants.

	Height(cm)	Weight(kg)	BMI(kg/m²)	BFM(kg)	LBM(kg)
HT(n=15)	163.07±4.98	58.47±6.95	22.00±2.59	15.59±4.67	42.87±3.77
GT(n=12)	160.79±4.33	59.79±9.26	23.10±3.32	17.58±5.54	42.21±4.29
Con(n=12)	161.78±5.61	56.97±4.06	21.83±2.01	15.19±3.48	41.78±3.06

Note: All values are mean ± standard deviation. BMI; body mass index. BFM; body fat mass, LBM; lean body mass.

2.2. Measurement and methods

2.2.1 Body composition

Height(cm) and weight(kg) were measured using an anthropometric stadiometer(BSM370, Bio-space, Korea). Weight(kg), Body Mass Index(kg/m^2), Percent Body Fat(%), Body Fat Mass(kg), Lean Body Mass (kg), and Skeletal Muscle Mass(kg) were measured using a body composition analyzer(Inbody 570, Korea) measured by bioelectrical resistance method. Before measuring, remove your shoes and socks, remove any metal objects, stand on a step stool, hold the handle with both hands, keep your arms straight down, and spread your armpits away from your body. Body circumference was measured at the triceps, forearm, chest, abdomen, waist, hip, femur, and lower leg(8 items) using a flexible, non-stretchable tape measure, and subcutaneous fat thickness was measured at the triceps, biceps, subscapularis, chest, abdomen, superior iliac spine, femur, and axillary region using a digital caliper(skyndex, USA).

2.2.2. Physical fitness

2.2.2.1. Grip strength

To assess muscle strength, participants were asked to stand up straight with their feet shoulder-width apart, let their arms hang down naturally, leave enough space between their armpits and arms to fit a fist, and then pull the dynamometer with as much force as they could muster. Two measurements were taken, alternating between the right and left hand, to record the highest value.

2.2.2.2. Sit-up

Muscular endurance was measured by sit-ups, which were performed while lying on a bench, knees bent and raised to 90 degrees, hands clasped comfortably behind the head, elbows touching the knees in a single repetition for 30 seconds to record the maximum number of repetitions.

2.2.2.3. Vertical jump

Quickness was measured in the vertical jump, and the vertical jump is to measure the leaping power, and the subjects were asked to jump as high as possible while standing with their knees extended on a rubber plate with a sensor attached, and bending and extending their knees momentarily. However, no recoil was allowed before the jump, and the highest value was recorded after two measurements.

2.2.2.4. Sitting trunk flexion

Flexibility is measured by sitting up and forward bending, where you sit with your legs straight and locked together. Without recoil, extend your hands forward side by side with your palms facing up and record the distance you can extend your fingers. The highest value was recorded after 2 measurements.

2.2.2.5. Standing on one leg with eyes closed

Balance is measured by standing on the leg with eyes closed with one leg folded and held up. Once you're in position, close your eyes to start the measurement. The time is checked from the moment you close your eyes while raising your arm and leg at the same time, and the end point is when the raised leg falls down and touches the sleeping surface. This method measures the time in seconds from the initial pose to the end.

2.3. Exercise program

There are two types of exercise programs: home training and gym training, and the exercises are performed 3 times a week for 6 weeks for 1 set of 15 reps. The number of sets gradually increased as the program progressed, culminating in 4 sets of 15 reps in week 6. The exercise program consists of upper body strength, lower body strength, and abdominal(core) strength exercises, with the exception of abdominal strength, which is the same for both home and gym training programs. For each part, you can choose 3 out of 6 exercises for a total of 9 exercises, followed by 5 minutes of stretching and aerobic exercise as a warm-up, 5 minutes of main exercise(10 minutes for upper body, 10 minutes for core, and 10 minutes for lower body), and 5 minutes of cool-down stretching.

Also, the researcher take a video all the exercises performed by the participants for each of the home and gym training sessions for 6 weeks and provided them to all participants via SNS(KakaoTalk). Verbal feedback was provided to ensure that the participants performed the exercises in the correct way each week, and the researcher continuously checked the participation and performance of the exercises via smartphone messenger. The composition of the exercise program is shown in <Table 2> and <Table 3>.

Table 2. Home training exercise program.

<table>
<tr><th></th><th>Type</th><th>Time(min)</th><th>Intensity</th></tr>
<tr><td>Warm up</td><td>Stretching</td><td>5min</td><td></td></tr>
<tr><td rowspan="6">Upper body</td><td>Push up</td><td rowspan="8">40min</td><td rowspan="12">1week
-15rep 1set,

2~3week
-15rep 2set,

4~5week
-15rep 3set,

6week
-15rep 4set</td></tr>
<tr><td>Pulse down</td></tr>
<tr><td>Arm walk</td></tr>
<tr><td>Cobra days</td></tr>
<tr><td>Shoulder taps</td></tr>
<tr><td>Superman</td></tr>
<tr><td rowspan="6">Abdominal exercise</td><td>Flank</td></tr>
<tr><td>Mountain climer</td></tr>
<tr><td>Scissor clap</td><td rowspan="4">40min</td></tr>
<tr><td>In & out</td></tr>
<tr><td>Cycling</td></tr>
<tr><td>Butterfly crunch</td></tr>
</table>

Lower body	Back lunge + knee up		
	Side lunge		
	Forward lunge		
	Squat side leg raise		
	Squat toe touch		
	Side toe tap		
Cool down	Stretching	5min	

Table 3. Gym training exercise program.

	Type	Time(min)	Intensity
Warm up	Stretching	5min	
Upper body	Long pull	40min	1week -15rep 1set, 2~3week -15rep 2set, 4~5week -15rep 3set, 6week -15rep 4set
	Lat pull down		
	Side lateral raise		
	Back extension		
	Bent over barbell-low		
	Shoulder press		
Abdominal exercise	Flank		
	Mountain climer		
	Scissor clap		
	In & out		
	Cycling		
	Butterfly crunch		
Lower body	Leg press		
	Leg curl		
	Leg extension		
	Hip abduction		
	Squat		
	Forward lunge		
Cool down	Stretching	5min	

2.4. Experimental procedures

The two exercise programs used in this study were designed by the researchers themselves, and the participants were given a video demonstration of the correct movements and exercises to perform before the experiment. Before entering the experiment, a pretest was conducted to measure body composition and physical fitness, and then the experiment was conducted. After six weeks of exercise, the posttest was conducted in the same way as the pretest. In addition, to check the progress of the experiment, after performing the exercise for one week, the participants were asked to fill in the personal exercise checklist distributed by the researcher before the experiment by writing down the type of exercise, number of exercises, number of sets, and exercise time(start time, end time) for each day. A total of 39 researchers participated in the study, including 15 in the home training group, 12 in the gym training group, and 12 in the control group, excluding those who gave up(four in the control group) due to personal circumstances and injuries in daily life.

2.5. Statistical analysis

For data processing in this study, SPSS 27.0 statistical program was used to calculate the mean and standard deviation of each measurement item, and two-way analysis of variance with repeated measures was conducted to examine the effect of each item by group and measurement time. When interactions were significant, a paired samples t-test was performed to analyze differences in the means of the dependent variables between time points within the same group, and a one-way analysis of variance was performed to analyze differences in the means of the dependent variables between groups at the same time point. The level of statistical significance between all measures was $p<.05$.

3. Results

Here are the results of a six-week study of female college students to determine the before-and-after effects of home training.

3.1. Body composition

The results of the analysis of changes in body composition by group and time after the exercise program are shown in <Table 4>. As shown in <Table 4>, the main effect of period was significant($p<.05$) for body weight, LBM, and skeletal muscle mass, and there was no significant difference in the group interaction. Post hoc tests of the main effect of time showed a significant difference in body weight, but the post hoc tests showed no significant difference from pre to post in all groups.

Table 4. Changes in body composition across groups and time periods.

Group	Weight(kg)		BMI(kg/m²)		LBM(kg)		BFP(%)		SMM(kg)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
HT	58.47 ±6.95	58.49 ±7.25	22.00 ±2.59	21.91 ±2.56	42.87 ±3.77	42.87 ±4.15	26.26 ±5.52	26.28 ±5.70	23.52 ±2.32	23.56 ±2.54
GT	59.79 ±9.26	60.24 ±9.75	23.10 ±3.32	23.14 ±3.46	42.21 ±4.29	42.73 ±4.90	28.74 ±5.19	28.45 ±5.54	23.11 ±2.60	23.45 ±2.99
Con	59.97 ±4.06	57.81 ±4.26	21.83 ±2.01	21.96 ±1.86	41.78 ±3.06	42.68* ±3.32	26.51 ±4.73	26.06 ±4.60	22.94 ±1.74	23.48* ±1.90
Time	4.208*		0.144		5.021*		0.598		5.496*	
Group	0.401		0.826		0.094		0.836		0.074	
G*T	1.286		0.714		1.601		0.209		1.301	

Note: All values are mean±standard deviation, *p<.05, **p<.01, HG: home training group, GT: gym training, Con: control group, BMI: body mass index, LBM: lean body mass, BFP: body fat percentage, SMM: skeletal muscle mass.

3.2. Physical fitness

The results of the analysis of the changes in physical fitness by group and time after applying the exercise program are shown in <Table 5>. As shown in <Table 5>, the main effect of time period was significant(p<.01) in the vertical jump, grip strength(left), grip strength(right), sit-up, and standing on one leg with eyes closed. However, the group interaction did not show significant differences in any of the items. Post hoc tests of the main effect of time showed that the vertical jump was significantly(p<.05) higher in the HT group than in the pre-test, the grip strength(left) was significantly(p<.05) lower in the GT group than in the pre-test, and the sit-up was significantly(p<.01) higher in the HT group than in the pre-test.

Table 5. Changes in physical fitness across groups and time periods.

Group	Vertical jump		Grip strength(L)		Grip strength(R)		Sit-up		Sitting trunk flexion		SOLE-closed test	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
HT	34.14 ±6.23	36.09* ±6.55	27.42 ±4.49	26.65 ±3.29	29.83 ±4.49	28.56 ±4.18	28.13 ±4.82	29.67** ±4.75	21.73 ±5.44	23.02 ±4.22	65.33 ±57.91	49.07 ±5.28
GT	31.53 ±7.30	32.84 ±8.53	27.71 ±3.75	26.58* ±4.04	29.26 ±3.29	28.76 ±2.93	27.58 ±4.60	28.75 ±9.96	22.14 ±4.76	21.37 ±4.94	51.25 ±36.46	36.75 ±18.14
Con	30.83 ±4.05	31.85 ±4.21	28.42 ±4.34	27.41 ±3.52	29.63 ±5.23	29.30 ±4.56	24.83 ±3.30	28.28* ±5.12	19.05 ±6.66	18.62 ±7.57	71.67 ±51.33	42.33* ±29.95
Time	10.360**		5.843*		4.404*		8.586**		0.003		6.886*	
Group	1.348		0.208		0.038		0.670		1.557		0.520	
G*T	0.401		0.074		0.812		0.955		1.550		0.359	

Note: All values are mean±standard deviation, *p<.05, **p<.01.
HT: home training, GT: gym training, Con: control, SOLE-closed test: standing on one led eyes closed test.

4. Discussion & Conclusion

4.1. Body composition

Body composition refers to the relative and absolute amounts of the elements that make up the body and includes body weight, body fat percentage, body fat mass, and skeletal muscle mass. An adequate amount of fat is an essential component of the human body and is often used to assess nutritional status. However, obesity, which is the accumulation of excess fat, is associated with metabolic diseases such as diabetes, hypertension, and cardiovascular disease, as well as musculoskeletal disorders, which threaten health[16].

The results of this study showed significant differences in body weight, LBM, and skeletal muscle mass between periods, but no significant differences between groups or interactions. LBM and skeletal muscle mass increased in the Con group after exercise, with no significant changes in BMI and body fat percentage. In line with these findings, a previous study reported that a 12-week online-based home training program for young adults resulted in significant differences in body weight, body fat, and body fat percentage, but not in muscle mass[17]. An eight-week program of non-face-to-face yoga in young adult men and women found that the exercise group reduced body fat percentage and body fat mass, contradicting a study that found statistically significant differences[18].

After 10 weeks of weight-bearing exercise in 26 middle-aged women, the researchers reported a significant decrease in body fat mass, body fat percentage, and a significant increase in skeletal muscle mass[19][20][21]. After a 12-week resistance training program in 17 obese middle-aged women, the researchers reported a decrease in body weight, body mass index, body fat percentage, and an increase in lean body mass in the exercise group[22].

They reported that 10 weeks of non-face-to-face real-time mat Pilates training was effective in improving body composition, cardiovascular function, and physical fitness in middle-aged obese women with prolonged sedentary behavior[23][24].

Comparing the results of this study with previous studies, it is believed that the relatively short duration of 6 weeks of exercise compared to 10-20 weeks of exercise in previous studies, and the low to moderate intensity of exercise may be insufficient to cause fat loss and increase skeletal muscle mass.

Therefore, follow-up studies should be conducted at a higher intensity for a longer period of time 10 weeks or more, and the number of subjects should be increased, as well as the proper distribution of groups in each group.

4.2. Physical fitness

In general, the elements of physical fitness that define physical fitness include strength, muscular endurance, cardiorespiratory endurance, flexibility, and agility, and the fundamental goal of improving physical fitness is to satisfactorily perform tasks that require muscular movement by increasing strength, endurance, and coordination and by maintaining or improving flexibility and joint range of motion[25][26].

The results of this study showed significant differences between the periods in the vertical jump, grip strength(left), grip strength(right), sit-ups, and standing on one leg with eyes closed, except for the sitting trunk flexion. After the exercise, the HT group showed a significant increase in vertical jump and sit-ups, while the GT group showed a tendency to decrease grip strength(left).

A previous study reported that 45 elderly women participated in a 10-week resistance exercise program using elastic bands and found that the exercise group increased their handgrip strength after 10 weeks, while no significant difference was found in latissimus dorsi strength[27][28].

This study compared fitness factors by exercise type and intensity in 60 middle-aged women. The results showed a greater increase in muscle strength in the moderate and high-intensity resistance exercise groups than in the low-intensity resistance exercise group[29]. This study found a significant increase in quickness of movement based on the timing of the measurements. A previous study reported that 12 weeks of high-intensity interval training at an intensity of 70-80% of HRmax in girls with body fat over 30% showed an increase in the experimental group, but the difference was not statistically significant[30].

In this study, changes in body composition and physical fitness were measured before and after exercise performance using an investigator-designed exercise program. However, since physical fitness includes muscular strength, muscular endurance, cardiorespiratory endurance, and flexibility, and other physical fitness items are very important for maintaining daily life at all ages, not just adults, it is necessary to verify the effectiveness of the program in improving physical fitness in various age groups and genders in subsequent studies. Since this study is a case study, it is not possible to directly compare the results. In addition, the literature for direct comparison is very limited, so we believe that more research in this direction is needed in the future.

This study analyzed the effects of a home training and gym exercise program designed by the researcher on body composition and physical fitness in female college students by applying 15 repetitions per set three times a week for six weeks. Based on the results, the following conclusions were drawn. In terms of body composition, there were significant differences in body weight, LBM, and skeletal muscle mass between periods, but there were no differences between groups. Therefore, it is considered somewhat insufficient to distinguish the effects of home training and gym training, and it is difficult to confirm the effect of home training because there was no difference with the control group.

However, since the home training group showed an increase in in vertical jump and sit-ups from pre- to post-training, the effectiveness of the training can be somewhat confirmed, but it is difficult to draw a clear conclusion. Therefore, further research is needed to determine the effectiveness of home training.

5. References

5.1. Journal articles

[1] An JH. The Effect of Exercise Constraints on Life Satisfaction due to Covid-19 among Elderly Who Participate in Continuous Sport-for-All : The Mediating Effects of Covid-19 Depression. *The Korean Journal of Sport*, 19(2), 411-421 (2021).

[2] Lee RD & Kang YJ & Hwang MH. The Relationship between Physical Activity Level and Arterial Stiffness in Young Female Adults. *Exercise Science*, 28(3), 232-239 (2019).

[3] Kim SH & Seo IH & Lee SM. Effect of at-home Workout Participant's Expectations on Perceived Value and Intention to Continue Exercise. *The Korea Journal of Sports Science*, 30(4), 421-432 (2021).

[5] Ahn SY & Park WI & Hong KS. Effects of 8-week Online-based Tabata Home Training on Body Composition, Health-related Physical Fitness, and Mental Health in Male Adolescents. *Asian Journal of Physical Education and Sport Science*, 10(2), 69-81 (2022).

[6] Kim YH & Park JH. The Influence of Participation Motivation in SNS Home Training Impacts on Psychological Well-being and Intention to Continue Exercise. *Journal of Leisure Studies*, 20(2), 17-38 (2022).

[7] Kim BY. Influence of Home Training Content Characteristics on Viewer's Viewing Engagement and Continuous Usage Intention: Focusing on YouTube Channel. *The Korean Journal of Sport*, 21(2), 327-337 (2023).

[8] Jung HS & Kim SY. Effects of Un-tact Strength Training Program for Body Composition, Basic Physical Strength and Anaerobic Power on University Student. *The Korean Journal of Sport*, 19(1), 545-552 (2021).

[9] Hyun AH & Cho JY. Effect of 8 Weeks Un-tact Pilates Home Training on Body Composition, Abdominal Obesity, Pelvic Tilt and Strength, Back Pain in Overweight Women after Childbirth. *Exercise Science*, 30(1), 61-69 (2021).

[10] So WY & Jun TW & Seo DI & Chang HK & Seo HK & Eom WS & Park ST & Park JY & Lee HJ & Park SK & Kim JH & Song W. Effects of 12 Weeks Elastic Band Exercise on Body Composition, Cardiorespiratory Function and Physical Fitness of Middle-aged Obese Women. *Journal of Obesity & Metabolic Syndrome*, 17(3), 132-140 (2008).

[11] Sonstroem RJ. Physical Estimation and Attraction Scales: Rationale and Research. *Medicine and Science in Sports*, 10, 97-102 (1978).

[12] Jung CK & Lee WK. Following 12 Weeks of Non-face-to-face Home Training for Male and Female College Students, Changes in Body Composition and Physical Self-concept. *The Korean Journal of Sport*, 20(4), 45-454 (2022).

[13] Lee JH & Min HJ. The Effect of Physical Self-efficacy of Women Participating in Group Exercise on Exercise Persistence and Life Satisfaction. *Journal of Coaching Development*, 23(1), 55-63 (2021).

[14] Shin JW & Lee KI. A Differences in the Quality of Life of Adults after Untact At-home Workouts Participation During the Covid-19 Pandemic. *The Journal of Humanities and Social Science*, 14(2), 2615-2627 (2023).

[15] Kim EY. Influence of Stress on Self-esteem and the Moderating Effects of Physical Activities in Korean Elderly People. *Kinesiology*, 1(1), 8-13 (2016). [Read More]

[16] Hales CM & Fryar CD & Carroll MD & Freedman DS & Ogden CL. Trends in Obesity and Severe Obesity Prevalence in US Youth and Adults by Sex and Age, 2007-2008 to 2015-2016. *The Journal of the American Medical Association*, 319(16), 1723-1725 (2018).

[17] Seo MS & Hur SE & Lee JS & Park SH & Moon HW. Changes of Adult Men and Women's Body Composition and Physical Capacity by Mobile Device Training for 12weeks. *The Korea Journal of Sports Science*, 26(2), 1149-1157 (2017).

[18] Cho IH & Eo KT & Kwak DM. The Effects of 8-week Online Yoga Training on Body Composition, Muscle Activity, Flexibility, and Balance. *Korean Journal of Sport Science*, 33(3), 349-358 (2022).

[19] Park JM & Kim SY & Jang CH. Effect of Weight Bearing Exercise on Health Related Fitness and Vascular Compliance in Middle Aged Women. *Journal of Sport and Leisure Studies*, 79, 421-429 (2020).

[20] Lee G & Kim K. The Effect of 12-weeks of Fitness Program on Physical Fitness Metabolic Risk Factors, and Cognitive Function of Aged Women with Mild Dementia. *Kinesiology*, 5(2), 40-53 (2020). [Read More]

[21] Park JS & Kim JH & Kim KJ. Relationship between Body Composition, Physical Fitness, and Blood Variables in Elementary School Girls. *Kinesiology*, 5(1), 21-32 (2020). [Read More]

[22] Kim SH. Effects of 12 Weeks of Resistance Exercise on Body Composition, Blood Lipid, Leptin and CRP in Middle-age Obese Women. *The Korea Journal of Sports Science*, 27(4), 767-777 (2018).

[23] Choi JH & Choi KE & Lee MG. Effects of Online Live Pilates Training during the Covid-19 Pandemic on Body Composition, Cardiovascular Function, and Physical Fitness in Sedentary Middle-aged Obese Women. *Korean Journal of Sport Science*, 33(4), 521-534 (2022).

[24] Hwang JA & Yoon JH & Park HS & Oh JK. Effect of Face-to-Face and Untact Pilates Exercises during 12 Weeks on Physical Fitness, Range of Motion, and Quality of Life in Young Women. *The Korean Journal of Sport*, 21(1), 447-458 (2023).

[25] Kim KL & Kim TW. The Effects of Flexibility Training on Health Related Fitness in Healthy Adults. *The Korean Journal of Physical Education*, 39(2), 285-293 (2000).

[26] Park J & Yoon D & Kim M & Son M. Comparison of Physique and Physical Fitness Factor Characteristics of College Taekwondo Majors by School Year. *Kinesiology*, 7(1), 1-10 (2022). [Read More]

[27] Jung AR & Lee DT. Effects of Resistance Exercise on Improvement of Muscular Strength and Endurance according to ACE Genotype in the Elderly Women. *Journal of Coaching Development*, 6(3), 291-298 (2004).

[28] Park JM & Hyun KS & Lee KS & Yoon JG & Kim SD. Effects of Band Resistance Exercise and Balance Training on Improvement of Sports Injury and Performance of Men's University Bowling Players. *Kinesiology*, 2(1), 7-16 (2017). [Read More]

5.2. Thesis degree

[4] Heo SY. Analysis of Consumption Patterns and Information Production Strategies of the Participants in the Home Workout. Hanyang University, Doctoral Thesis (2019).

[29] Lee SH. Effect of Exercise Type and Intensity on Health Related with Physical Fitness Factors and Metabolic Syndrome Risk Factors in Middle-aged Women. Catholic Kwandong University, Doctoral Thesis (2016).

[30] Ha MS. The Effect of Repetition and Interval Aerobic Exercise on Physical Fitness and Physiological Variables In Obese Middle School Girls. Kangwon National University, Doctoral Thesis (2008).

6. Appendix

6.1. Author's contribution

	Initial name	Contribution
Lead Author	HJ	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑
Corresponding Author*	WC	-Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	HS	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑