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Original Article

Comparing the Effectiveness of Flexi-Bar and Multi-Component Exercises on Improving the Physical Health of Older Adults: A Randomized Controlled Trial

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SUMMARY

Background: Both Flexi-Bar and Multi-Component exercises can improve an individual's physical fitness and musculoskeletal discomfort. However, determining which is more effective in enhancing the physical fitness, and musculoskeletal discomfort of older adults remains controversial.
Objective: This study aims to investigate differences in the effectiveness of Flexi-Bar and Multi-Component exercises in improving the frailty, physical fitness, and musculoskeletal discomfort of older adults after 12 weeks of intervention.
Methods: A single-blind randomized controlled trial was conducted to collect data in central Taiwan. Participants were randomly assigned into a Flexi-Bar group (FB group) and a Multi-Component exercise group (MCE group). Participants in the FB group performed a 60-minute Flexi-Bar exercise every week for 12 consecutive weeks; participants in the MCE group performed a 60-minute Multi-Component exercise every week for 12 consecutive weeks. Before and after the intervention, the assessment was conducted using the Kihon Checklist, Senior Fitness Test, and Nordic Musculoskeletal Questionnaire.
Results: A total of 80 participants (16 males) were recruited (age = 75.7 ± 7.3 years). The results showed that the improvements of the FB group participants in the 2-minute step test, back scratch test, and number of body parts with discomfort were more significant than those of the participants in the MCE group.
Conclusion: This study found that the cardiopulmonary function, upper body flexibility, and musculoskeletal discomfort of the FB group participants improved more significantly than those in the MCE group. This finding indicated that a Flexi-Bar exercise was a more effective intervention for older adults than a Multi-Component exercise.

1. Introduction

Physiological changes in older adults during aging are often complicated and can be triggered by both genetics and diseases. Declining physiology can cause frailty, deteriorating physical fitness, and musculoskeletal discomfort, which leads to disability and compromised quality of life.[1] Multiple studies[2–4] have confirmed that regular exercise can not only delay frailty and improve physical fitness (e.g., physical resilience) among older adults, but also benefit them by reducing the incidence of musculoskeletal discomfort, risk of falling, and cost of health insurance and medical expenses. However, it is important to provide older adults with an effective and empirical basic exercise that can benefit their physical fitness.

Caring for frail older adults has become a public health issue that requires urgent attention, as it influences older adults' personal lives and causes a significant burden on the family (financially) and the nursing community due to the lack of resources.[5] In Taiwan, the prevalence of frailty among older adults over 65 years old is 5.4%, of which 41.5% are in the early stage of frailty. Additionally, this prevalence increases with age, reaching 20% to 30% among older adults over 75 years old.[6] Early stage frailty can be diagnosed by observing the declining physical fitness of older adults. In other words, it is possible to reduce the risk of frailty among older adults by improving their physical fitness.

The aging process can cause loss of cartilage resilience and muscular mass, resulting in decreased muscle strength and ligament elasticity, leading to limited joint motion and musculoskeletal pain or soreness during daily activities.[7] Furthermore, older adults are more likely to suffer from low back pain, frozen shoulder, and degenerative osteoarthritis, which can easily introduce musculoskeletal pain and discomfort.[8] In contrast, exercises can effectively alleviate musculoskeletal discomfort, improve body flexibility, and stabilize core muscles.

The American College of Sports Medicine (ACSM) recommends that, to improve various physical abilities, rather than a single form of exercise, older adults should choose a Multi-Component exercise to improve the comprehensiveness of the exercise, as it includes aerobic, resistance, flexibility, and balance training.[9] A systematic reviews has also shown that, for frail older adults, a Multi-Component exercise, compared to a single type of training, is the optimal

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intervention as it can improve more aspects of older adults' general health, such as their gait, balance, muscle strength, and risk of falling.

Alternatively, gentle exercises with medium or low intensity that focus on balance and flexibility and minimize sports injuries should be prescribed for older adults with chronic disease(s) (such as high blood pressure, cardiovascular diseases, and osteoporosis), poor balance, and fear of falling.[10,11] Vibration exercises are exercises that are coupled with medium to low amplitude, balance, and flexibility, and are safer.[12] Comprising low-frequency and low-amplitude movements, vibration exercises provide muscles with safe and effective proprioceptive stimulation and can enhance physical functions as well as neuromuscular performances.[13] As the most popular and effective vibration exercise, Flexi-Bar exercises have proven to stabilize core muscles,[14] improve balance,[15] reduce musculoskeletal discomfort,[16] and enhance the physical fitness of older adults.[17] The safety and efficacy of Flexi-Bar exercise in older adults with special diseases (such as stroke) have been well verified.[18]

The above literature review indicates that both Flexi-Bar and Multi-Component exercises are somewhat effective in improving frailty, physical fitness, and musculoskeletal discomfort. However, determining which is more effective in enhancing the frailty, physical fitness, and musculoskeletal discomfort of older adults remain controversial, preventing us from choosing the optimal intervention for older adults. Therefore, the purpose of this study was to explore the effectiveness of Flexi-Bar and Multi-Component exercises in improving the aforementioned conditions of older adults after 12 weeks of intervention. Additionally, differences in the effectiveness of the two exercises were compared.

2. Methods

2.1. Study design and participants

This study was a single-blind randomized controlled trial (participants were blinded). This study collected data in Taichung City in central Taiwan. Participants were randomly assigned into a Flexi-Bar group (FB group) and Multi-Component exercise group (MCE group) according to the blocked randomization method (1:1), each consisting of 40 participants. The study period spanned from September 2020 to January 2021. During this period, participants in the FB group performed a 60-minute Flexi-Bar exercise every week for 12 consecutive weeks, whereas participants in the MCE group performed a 60-minute Multi-Component exercise every week for 12 consecutive weeks. Tests were conducted both before and after the 12-week intervention using items including primary outcomes: the Kihon Checklist (KCL), and Senior Fitness Test (SFT); secondary outcome: Nordic Musculoskeletal Questionnaire (NMQ). In addition, the FB group and the MCE group were led by two coaches, respectively; the pre-and post-test evaluations were conducted by the same research assistant.

The inclusion criteria were: (1) participants aged 65 years and over; (2) participants who could communicate in Mandarin or Taiwanese and cooperate with sports activities; and (3) participants who could walk independently without assistance (or with aid). The exclusion criteria were: (1) participants with unstable physiological conditions (or those who were recommended against participating in physical activities by their doctor); (2) participants with unstable mental conditions; and (3) participants who could not complete the

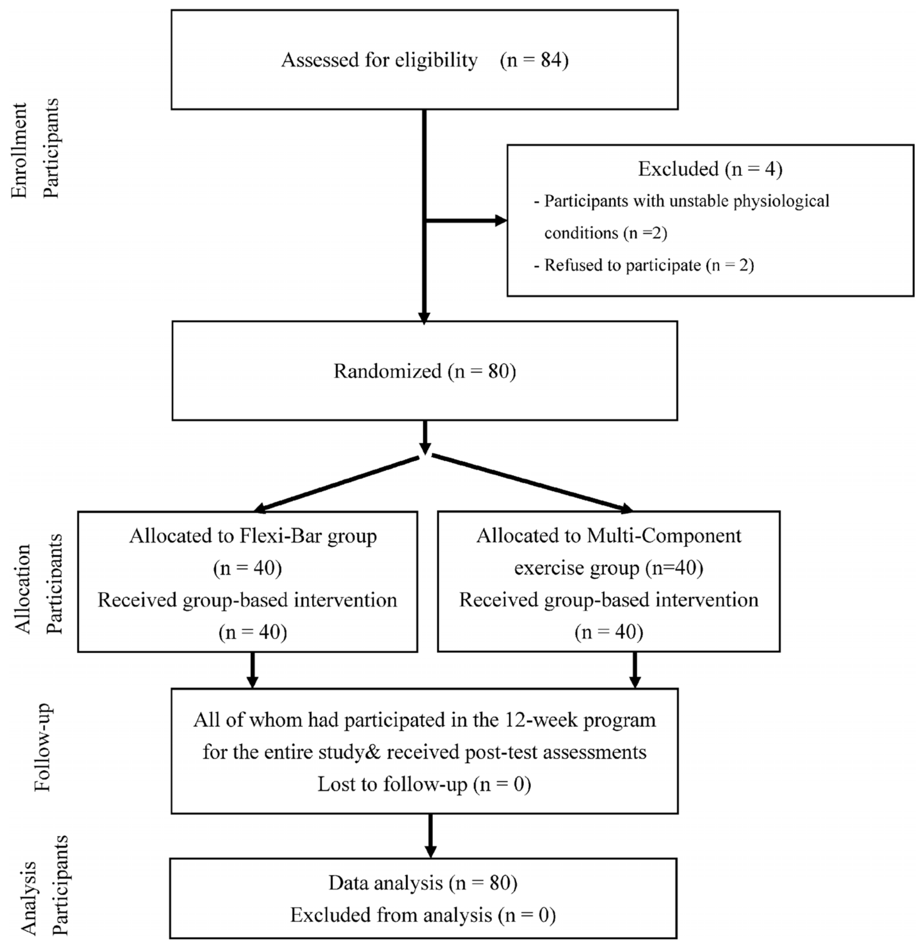

Figure 1. Flow chart of participants through study.

12-week exercise intervention. Additionally, prior to the SFT, the researchers were first trained on data collection. The same researchers subsequently evaluated the pre-and post-exercise SFT scores of each participant. The sample size was estimated using G-power software (3.1.0). Referencing a previous study,[17] a sample of 40 participants per group allowed us to detect a difference between these two groups, with a power of 85% and an alpha level of 0.05. In addition, this study is registered in the ClinicalTrials.gov Protocol Registration and Results System (NCT05025137). This study was approved by the Regional Ethics Committee of the Central Region of China Medical University (CRREC-109-088).

2.2. Intervention methods

In the experimental group, the Flexi-Bar was adopted as the tool for active vibration exercises. Featuring light weight and ease of operation, it weighs only 460 grams and has a vibration frequency of 4–5Hz. With diversified functions, the Flexi-Bar can improve posture, burn fat, strengthen connective tissue, enhance body shape, and increase muscle strength.[16] The course, composed of one 60-minute class per week for a total of 12 weeks, progressed gradually from basic activities to advanced activities (progressive course).

Each class started with a 10-minute warm-up exercise, that was carried out in a sitting posture to reduce sports injuries and increase physical flexibility. This was followed by the main exercise, consisting of 40 minutes of Flexi-Bar exercises that were separated into two sessions by a 5- to 10-minute break. The main exercise, which gradually progressed from basic to advanced activities, achieved the vibration of the entire body by vibrating the upper and lower body muscles to stretch the core muscles. The class was concluded by a 10-minute cool-down exercise, during which participants performed static stretching exercises in a sitting posture to reduce post-exercise muscle tightness and soreness caused by the accumulation of lactic acid by properly relaxing the muscles.

Alternatively, in the MCE group, the Multi-Component exercise was adopted, which included aerobic, resistance, flexibility, and balance exercises. The course was composed of one 60-minute class per week for a total of 12 weeks. The design was based on the ACSM's recommendations for the multiple-component exercise of older adults[19] and videos of the National Health Exercises for the older adults formulated by the Ministry of Health and Welfare.[20] Additionally, the intensity of the exercises was adjusted according to the participants' physical conditions; fitness equipment was introduced when appropriate (progressive course).

Each class started with a 10-minute warm-up flexibility exercise carried out in the sitting posture. The main exercise followed and was divided into two sessions of aerobic and resistance exercises (alternated with a balance exercise) that were separated by a 5- to 10-minute break. During the first three weeks, the main exercise was carried out in the sitting posture with the aid of the chair back. The posture was subsequently adjusted to a standing posture from the fourth week of the course, depending on the participants' condition. The class was concluded by a 10-minute cool-down flexibility exercise, during which participants relaxed, stretched various muscle groups, and gradually extended the range of joint activities in the sitting posture.

2.3. Research tools

The research tools used in this study mainly consisted of four parts. The first part was the participants' basic demographics, including gender, age, BMI (InBody 720), marital status, education level, smoking habit, drinking habit, number of weekly exercises (with a duration greater than 30 minutes), and number of chronic diseases. The second part investigated the participants' degree of frailty via the KCL. The KCL consists of 25 True or False questions and covers seven aspects, including living independence, exercise function, nutrition, oral function, social interaction, dementia, and depression. The total score of all items, which ranged between 0 and 25, was then used to evaluate the participant's frailty. Participants with a score of 10 and greater were categorized as the frail population. The higher the score, the higher the degree of frailty. The reliability and validity of the Chinese version of the KCL was well verified.[21] In this study, the Cronbach's alpha of the pre- and post-exercise KCL in both the FB group and the MCE group ranged between 0.71 and 0.84.

The third part adopted the SFT to assess changes in participants' physical fitness. The SFT was designed by Rikli, Jones[22] to assess the physical fitness of older adults in daily activities. It includes six tests, namely (1) chair stand test, which counts the number of stands a participant can complete in 30 seconds and reflects the strength of the lower body; (2) arm curl test, which requires the participant to lift a dumbbell repeatedly in 30 seconds, counts the number of completed bicep curls, and reflects upper body strength; (3) 2-minute step test, which counts the number of steps completed in two minutes and reflects the cardiopulmonary function; (4) chair sit-and-reach test, which requires the participant to sit on a chair and stretch his/her hands forward to reach the toes, and then measures the distance between the hands and the toes. Distances short of reach are recorded as negative values (cm), whereas distances beyond reach are recorded as positive values (cm). This test reflects lower body flexibility; (5) back scratch test, which requires the participant's one hand to reach over the shoulder and the other up the middle of the back, and then measures the distance between the middle fingers of both hands. Distances short of reach are recorded as negative values (cm), whereas distances beyond reach are recorded as positive values (cm). This test reflects upper body flexibility; and (6) eight-foot up-and-go test, which calculates the time the participant requires to get up from a seated position, walk 8 ft, turn around at the marker, and return to the original position to sit down. This test reflects agility and dynamic balance. The SFT provides a comprehensive and easy way to assess the physical fitness of adults aged over 60 years, and its reliability and validity have been well verified.[23]

The fourth part investigated musculoskeletal discomfort via the NMQ. Developed by Kuorinka, Jonsson, Kilbom, Vinterberg, Biering-Sørensen, Andersson, Jørgensen[24] the NMQ asks participants whether they have experienced pain, soreness, numbness, tingling, or any other discomfort in 15 body parts on both sides (including neck, shoulders, upper back, elbows, lower back or waist, hands or wrists, hips or thighs, and knees and ankles or feet). The human body illustration in the questionnaire allows participants to easily and clearly identify the location of musculoskeletal discomfort. The number of body parts with discomfort is then calculated by adding the number of locations experiencing any discomfort. The reliability and validity of the NMQ in assessing musculoskeletal discomfort have been well verified.[25]

2.4. Statistical analysis

This study adopted the SPSS 25.0 for mac version (IBM Corp., Armonk, NY) for data analysis, and the significance level was set at $\alpha = 0.05$. Participants' demographic data were presented by descriptive statistics, and whether the difference between the FB and MCE groups was significant was examined by Fisher's exact test and Student's t-test. Alternatively, as the variables in the study were not distributed normally, the Wilcoxon signed-rank test was introduced to see if there were any significant differences in the KCL, SFT, and number of body parts with discomfort before and after the intervention in both the FB group and MCE group. Subsequently, the Mann-Whitney U test was utilized to examine whether the absolute differences (i.e., "after intervention" minus "baseline") of the KCL, SFT, and number of body parts with discomfort were significantly different between the two groups. Additionally, participants in both groups were divided into frail and non-frail categories according to their pre-exercise KCL scores.

3. Results

3.1. Basic demographics

This study recruited a total of 80 participants in the study, all of whom successfully completed the 12-week intervention. The basic demographics, Fisher's exact test results, and Student's t-test results from these participants are listed in Table 1. The FB group consisted of 12 males and 28 females, and the average age was 75.1 years; the MCE group consisted of 4 males and 36 females, and the average age was 76.2 years. Both Fisher's exact test and Student's t-test results indicated that there was no significant difference in the basic demographic data between the FB group and MCE group. In addition, there was no significant difference in pre-test scores (including KCL, SFT, and number of body parts with discomfort) between the two groups.

3.2. Comparing the changes in the Kihon Checklist, the Senior Fitness Test, and musculoskeletal discomfort after intervention

The average, median, and Wilcoxon signed-rank test results of the KCL, SFT, and number of body parts with discomfort are listed in Table 2. In the FB group, the scores of the 2-minute step test, chair sit-and-reach test, and back scratch test of the SFT, as well as the number of body parts with discomfort showed significant differences between the pre- and post-exercise tests ($p < 0.05$–0.01). This finding indicated that after introducing the Flexi-Bar, participants' cardiopulmonary function and lower and upper body flexibility improved substantially, while the number of body parts with discomfort dropped considerably. Alternatively, in the MCE group, the score of the chair sit-and-reach test of the SFT as well as the number of body parts with discomfort showed significant differences between the pre- and post-exercise tests ($p < 0.05$–0.01), indicating that participants' lower body flexibility significantly improved and their number of body parts with discomfort substantially dropped following the intervention of the Multi-Component exercise.

3.3. Comparison of post-exercise changes in the Kihon Checklist, the Senior Fitness Test, and musculoskeletal discomfort between the two groups

The results of the Mann-Whitney U test listed in Table 3 show significant differences in the 2-minute step test and the back scratch test of the SFT, as well as the number of body parts with discomfort between the two groups ($p < 0.05$–0.01). This finding indicated that improvements in the cardiopulmonary function, upper body flexibility, and the number of body parts with musculoskeletal discomfort were more obvious in the FB group than in the MCE group. Subsequently, participants in both groups were further divided into non-frail and frail categories, and the results of the Mann-Whitney U test conducted between these two categories are listed in Appendices 1 and 2. Among non-frail participants, both the KCL score and number of body parts with discomfort showed significant differences ($p < 0.05$), which indicated that non-frail participants in the FB group improved more substantially in frailty and the number of body parts with musculoskeletal discomfort than their counterparts in the MCE group. Alternatively, among frail participants, the 2-minute step test

Table 1
Demographic characteristics of the participants in the two groups.

Demographic characteristics	Flexi-Bar group (n = 40)	Multi-Component exercise group (n = 40)	Fisher's Exact Test (*p*-value)
Gender			0.24
Male	12	4	
Female	28	36	
Age (mean ± SD)	75.1 ± 5.1	76.2 ± 9.1	0.64[a]
BMI (mean ± SD)	24.5 ± 3.3	23.4 ± 3.6	0.33[a]
Marital status			0.34
Single/divorced/widowed	18	26	
Married/cohabiting	22	14	
Years of education			1.00
≤ 9 years	30	32	
> 9 years	10	8	
Smoking habit			1.00
Yes	2	0	
No	38	40	
Drinking habit			1.00
Yes	0	2	
No	40	38	
Exercise per week			0.24
≤ 3 days	4	12	
> 3 days	36	28	
Chronic diseases (mean ± SD)	3.7 ± 4.0	3.9 ± 4.3	0.88[a]
KCL (pre-test)			1.00
< 10 (non-frail)	24	24	
≥ 10 (frail)	16	16	

[a] *t*-test.
BMI: body mass index; KCL: Kihon Checklist; SD: standard deviation.

Table 2

Comparing the changes in the Kihon Checklist, the Senior Fitness Test, and musculoskeletal discomfort after intervention.

Outcome variable	Flexi-Bar group (n = 40)					Multi-Component exercise group (n = 40)				
	Pre-test		Post-test		*p*-value	Pre-test		Post-test		*p*-value
	Mean (SD)	Median value (IR)	Mean (SD)	Median value (IR)	Wilcoxon signed-rank test	Mean (SD)	Median value (IR)	Mean (SD)	Median value (IR)	Wilcoxon signed-rank test
KCL	7.45 ± 2.76	7.00 (5.25–10.00)	7.05 ± 3.17	6.50 (5.00–10.00)	0.13	9.30 ± 5.13	8.00 (6.00–12.00)	9.65 ± 4.11	8.50 (7.00–12.00)	0.59
SFT										
BMI	24.49 ± 3.34	24.16 (22.30–26.48)	24.09 ± 3.69	23.65 (21.23–26.43)	0.13	22.42 ± 3.55	23.25 (20.35–25.03)	23.42 ± 3.87	23.25 (20.15–25.53)	0.68
Chair stand up for 30 seconds (repetitions)	13.80 ± 4.11	14.50 (10.25–17.50)	15.35 ± 6.13	12.50 (11.00–21.75)	0.07	13.75 ± 7.35	12.50 (7.50–18.75)	13.50 ± 6.30	12.00 (9.25–17.50)	0.68
Arm curl (repetitions)	22.95 ± 6.53	22.00 (18.50–29.00)	22.20 ± 6.07	20.00 (18.25–26.75)	0.62	22.45 ± 5.46	22.50 (18.25–26.75)	22.30 ± 5.89	22.00 (20.00–27.00)	0.70
2-minute step test (repetitions)	58.40 ± 22.88	52.50 (43.00–77.00)	72.15 ± 18.60	70.50 (54.25–90.75)	0.01**	58.45 ± 17.79	50.00 (47.00–70.25)	57.35 ± 21.13	50.00 (46.25–68.75)	0.72
Chair sit and reach (cm)	0.90 ± 15.85	0.00 (-12.75–9.75)	6.80 ± 11.49	2.50 (-1.00–13.25)	0.03*	3.70 ± 8.78	3.00 (0.50–8.00)	6.65 ± 7.33	5.00 (3.25–5.00)	0.01*
Back scratch (cm)	-9.35 ± 9.13	-10.50 (-16.75–-10.50)	-3.80 ± 10.53	-5.50 (-12.00–6.00)	0.02*	-6.05 ± 11.99	-5.00 (-14.25–2.25)	-6.30 ± 14.32	-2.00 (-14.25–4.50)	0.92
8-foot up and go (seconds)	9.35 ± 4.27	8.45 (6.79–10.86)	9.00 ± 4.01	8.46 (5.76–11.18)	0.37	9.15 ± 5.00	7.21 (5.82–11.95)	8.73 ± 4.14	7.27 (5.72–10.82)	0.27
The number of body parts with discomfort	3.00 ± 1.56	2.00 (2.00–4.75)	1.10 ± 0.97	1.00 (0.25–1.00)	0.00**	3.40 ± 1.67	4.00 (2.00–4.00)	2.75 ± 1.45	3.00 (2.00–4.00)	0.01**

IR: interquartile range; KCL: Kihon Checklist; SD: standard deviation; SFT: Senior Fitness Test.

* $p < 0.05$; ** $p < 0.01$.

Table 3

Comparison of post-exercise changes in the Kihon Checklist, the Senior Fitness Test, and musculoskeletal discomfort between the two groups.

Outcome variable	Flexi-Bar group (n = 40)		Multi-Component exercise group (n = 40)		*p*-value
	Mean (SD)	Median value (IR)	Mean (SD)	Median value (IR)	Mann-Whitney U test
KCL	-0.40 ± 1.14	0.00 (-1.00–0.00)	0.35 ± 2.98	0.00 (0.00–1.00)	0.17
SFT					
BMI	-0.41 ± 1.89	-0.30 (-1.33–0.48)	-0.01 ± 0.68	0.00 (0.00–0.30)	0.17
Chair stand up for 30 seconds (repetitions)	1.55 ± 3.39	1.50 (-1.00–3.00)	-0.25 ± 3.55	0.00 (-2.00–0.00)	0.07
Arm curl (repetitions)	-0.75 ± 5.01	-1.00 (-3.00–3.00)	-0.15 ± 3.31	0.00 (-1.00–1.00)	0.40
2-minute step test (repetitions)	13.75 ± 19.56	11.50 (0.25–27.75)	-1.10 ± 11.29	0.00 (-9.25–1.00)	0.01**
Chair sit and reach (cm)	5.90 ± 10.03	6.00 (-2.00–13.75)	2.95 ± 5.52	1.00 (0.00–5.75)	0.58
Back scratch (cm)	5.55 ± 10.25	3.50 (0.00–9.00)	-0.25 ± 5.90	0.00 (0.00–0.00)	0.02*
8-foot up and go (seconds)	-0.35 ± 2.99	-0.58 (-1.69–0.78)	-0.43 ± 1.54	-0.03 (-0.50–0.07)	0.64
The number of body parts with discomfort	-1.90 ± 1.74	-1.00 (-3.00–-1.00)	-0.65 ± 0.88	-1.00 (-1.00–0.00)	0.02*

IR: interquartile range; KCL: Kihon Checklist; SD: standard deviation; SFT: Senior Fitness Test.

* $p < 0.05$; ** $p < 0.01$.

score of the SFT showed significant differences between the two groups, indicating that frail participants in the FB group improved more obviously in their cardiopulmonary function than their counterparts in the MCE group.

4. Discussions

Flexi-Bar and Multi-Component exercises have both become popular and effective in recent years. This study is likely one of the few that has compared their efficacy among older adults. Results in Table 2 suggested that participants in the FB group showed significant improvements in cardiopulmonary function, upper and lower body flexibility, and musculoskeletal discomfort, which is consistent with the findings of previous studies.[12,16,17] In contrast, participants in the MCE group showed significant improvements in lower body flexibility and musculoskeletal discomfort. Compared with previous studies,[26,27] participants in the MCE group in this study showed improvements in fewer SFT items, partly because some of the participants belonged to the frail category. Additionally, comparison of the efficacy of the Flexi-Bar and Multi-Component exercises (Table 3) showed that participants in the FB group had more obvious improvements in cardiopulmonary function, upper body flexibility, and musculoskeletal discomfort than their counterparts in the MCE group, indicating that Flexi-Bar exercises could be more beneficial to older adults.

Table 2 shows that participants in the FB group experienced significant improvements in cardiopulmonary function, upper and lower body flexibility, and musculoskeletal discomfort. The escalation of the cardiopulmonary function requires regular exercises with appropriate intensities that can promote multiple physiological functions such as neuromuscular coordination, cardiovascular circulation, and pulmonary ventilation. This long-term regulatory interference can then help form a new constant state of adaptation.[28] A previous study that introduced a 12-week intervention of Flexi-Bar exercises to adults showed that the Flexi-Bar exercise's active vibration features could help burn fat, improve cardiopulmonary function, and increase muscle strength. Additionally, based on the same principle, active vibration exercise can be considered equivalent to aerobic exercise and can therefore activate large muscle groups. With an appropriate intensity, it can effectively enhance cardiopulmonary function and metabolism.[17] Other benefits of vibration exercise include increasing flexibility, while its immediate effect on contractile and antagonist muscle activity can reduce joint stiffness.[29] Furthermore, under vibration stimulation, Ia inhibitory neurons can inhibit the performance of antagonist muscles and consequently promote joint movements that can change the viscosity of joints and increase the flexibility of soft tissues. Finally, vibration can also improve flexibility by accelerating cardiovascular circulation and raise tissue temperature.[30]

On one hand, most musculoskeletal discomfort and pain may be attributed to muscle weakness or joint instability.[31] On the other hand, the Flexi-Bar exercise helps stabilize core muscles, improve proprioception and body coordination, increase body strength, and reduce pain in the shoulder joint, waist, and lower back.[31,32] Additionally, a vibration exercise has the mechanism of reducing pain threshold and inhibiting pain input. According to the gate control theory of pain, vibration stimulation can reduce pain perception by reaching the brain before pain stimulation.[33] Humans cannot completely distinguish pain from other simultaneous sensory stimuli and tend to ignore unpleasant sensations, thereby making vibration sensation capable of reducing pain by reaching the brain first.[33] This may be why a substantial drop in the number of body parts with musculoskeletal discomfort was observed among the participants in the FB group.

Alternatively, participants in the MCE group showed significant improvements in lower body flexibility and musculoskeletal discomfort (Table 2), consistent with the findings of previous studies.[3,27] This is likely because the Multi-Component exercise already includes flexibility training, and an additional stretching exercise was performed as part of both the warm-up and the cool-down exercises in this study. Furthermore, a Multi-Component exercise (such as resistance and aerobic exercises) can increase bone density, prevent osteoporosis, and improve muscle strength, thereby helping alleviate the musculoskeletal discomfort of the general older adult population and patients with arthritis.[3,34,35] Flexibility exercises are also effective on common musculoskeletal pain (such as back pain).[36] However, unlike previous studies,[3,27] participants in our study did not show improvements in upper and lower body strength or in cardiopulmonary function, which is likely because the intervention only lasted for 12 weeks.

Results in Table 3 suggested that participants in the FB group showed more significant improvements in cardiopulmonary function, upper body flexibility, and musculoskeletal discomfort than their counterparts in the MCE group. A possible reason is that being a hand-held active vibration exercise, a Flexi-Bar exercise may be more suitable for older adults with frailty and poor balance than a Multi-Component exercise,[37] as the former can activate the deep core muscles of older adults and increase their static and dynamic stability. Therefore, participants felt more secure and confident during exercise, promoting them to participate in courses with higher intensities (higher exercise intensity is required to improve cardiopulmonary function). Additionally, compared to general flexibility exercises, a vibration exercise is more effective in increasing flexibility owing to its mechanism of increasing cardiovascular circulation, soothing pain, reducing musculoskeletal stiffness, and inhibiting muscular antagonist.[38] Furthermore, a low-frequency (such as 5 Hz) vibration exercise has not only been proven more effective than general exercise in reducing tendon stiffness and changing the characteristics of intramuscular connective tissue, but may also alter the characteristics of other bone structures that are related to the range of joint motion, such as knees.[39] Noteworthily, despite understanding its benefits, most older adults are reluctant to exercise due to associated pain.[39] By reducing the musculoskeletal discomfort during exercise, a Flexi-Bar exercise allows participants to focus on the training course and consequently achieve better results.

In this study, non-frail participants in the FB group showed more significant improvements in both frailty and musculoskeletal discomfort than their counterparts in the MCE group (Appendix 1). Alternatively, frail participants in the FB group showed more substantial improvements in cardiopulmonary function than their counterparts in the MCE group (Appendix 2). This result indicated that a Flexi-Bar exercise demonstrated positive effects on both non-frail and frail older adult participants. However, due to the limited sample size, further research is required to verify its efficacy among frail older adults.

4.1. *Limitations*

When interpreting the results of this study, readers should consider the following limitations. First, the KCL and NMQ scales adopted in this study were self-administered. Despite their popularity, good reliability, and validity, they could not represent the real frailty and musculoskeletal discomfort experienced by older adults. Second, not only were all participants recruited from central Taiwan, but the number of participants was small, which restricted the explanatory power of the study. Third, as this study was a randomized controlled experiment, the risk of bias could not be eliminated, although no significant differences of demographic variables were observed. Fourth, the study was carried out during the COVID-19 period. Given evidence[40–42] showing the impacts of COVID-19 on psychological parts of older people, and the consequences may further influence older people's physical performance. Last, the interventions introduced in this study were led by activity leaders. However, different leaders could have introduced different intervention outcomes. Therefore, it is recommended that further research be conducted to compare the effectiveness of Flexi-Bar and Multi-Component exercises among older adults. Despite these limitations, our study successfully compared differences between the efficacy of Flexi-Bar and Multi-Component exercises in improving the frailty, physical fitness, and musculoskeletal discomfort of older adults. The results of this study can provide an important reference for health professionals in choosing appropriate exercise interventions for older adults. In addition, future studies may want to further examine the two types of exercise effects on the psychosocial aspects of older people because empirical evidence shows that older people may have psychological-related health issues.[42–44]

5. Conclusion

This study showed that after 12 weeks of intervention, participants in the FB group showed significant improvements in cardiopulmonary function, upper and lower body flexibility, and musculoskeletal discomfort, while those in the MCE group showed significant improvements in lower body flexibility and musculoskeletal discomfort. Further comparison suggested that participants in the FB group experienced more substantial enhancements in cardiopulmonary function, upper body flexibility, and musculoskeletal discomfort than their counterparts in the MCE group, indicating that a Flexi-Bar exercise was more effective than a Multi-Component exercise in older adults. However, due to the limited sample size, further research may be required to validate the results of this study.

Conflicts of interest

The authors declare that they have no conflict of interest.

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Data accessibility statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical approval

This study was approved by the Research Ethics Committee of China Medical University Hospital (CRREC-109-088).

Supplementary materials

Supplementary materials for this article can be found at http://www.sgecm.org.tw/ijge/journal/view.asp?id=22.

References

1. Gheno R, Cepparo JM, Rosca CE, et al. Musculoskeletal disorders in the elderly. *J Clin Imaging Sci.* 2012;2:39.
2. Bray NW, Jones GJ, Rush KL, et al. Multi-Component exercise with high-intensity, free-weight, functional resistance training in pre-frail females: a quasi-experimental, pilot study. *J Frailty Aging.* 2020;9:111–117.
3. Levy SS, Macera CA, Hootman JM, et al. Evaluation of a multi-component group exercise program for adults with arthritis: fitness and exercise for people with arthritis (FEPA). *Disabil Health J.* 2012;5:305–311.
4. Hu FW, Lin CH, Lai PH, et al. Predictive validity of the physical resilience instrument for older adults (PRIFOR). *J Nutr Health Aging.* 2021;25: 1042–1045.
5. Buckinx F, Rolland Y, Reginster JY, et al. Burden of frailty in the elderly population: perspectives for a public health challenge. *Arch Public Health.* 2015;73:19.
6. Liao FM, Su YW, Kuo CS, et al. Effects of multicomponent exercises program intervention on functional fitness among community-dwelling elderly adults. *The Journal of Long-Term Care.* 2019;23:45–60. [In Chinese, English abstract]
7. Cooper G, Tatli Y, Lutz GE. Spine and musculoskeletal medicine. In: Cooper G, ed. *Essential Physical Medicine and Rehabilitation*. Humana Press; 2006:249–284.
8. Doriot N, Wang X. Effects of age and gender on maximum voluntary range of motion of the upper body joints. *Ergonomics.* 2006;49:269–281.
9. Haripriya S, Kumar D, Samuel SE, et al. Effect of a multi-component exercise program on functional mobility, exercise capacity and quality of life in older adults. *J Clin Diagn Res*. 2018;12:YC01–YC04.
10. Holmerová I, Machácová K, Vanková H, et al. Effect of the exercise dance for seniors (EXDASE) program on lower-body functioning among institutionalized older adults. *J Aging Health.* 2010;22:106–119.
11. Schultz MG, La Gerche A, Sharman JE. Blood pressure response to exercise and cardiovascular disease. *Curr Hypertens Rep.* 2017;19:89.
12. Dudonienė V. A comparison of flexi-bar and non-flexi-bar exercises effect on balance, walking speed and fall risk in older women. *J Health Sci Dev.* 2019. Available at https://www.innovationinfo.org/conferenceproceedings/27/Vilma_Dudoniene.pdf. Accessed March 11, 2021.
13. Chung JS, Park S, Kim J, et al. Effects of flexi-bar and non-flexi-bar exercises on trunk muscles activity in different postures in healthy adults. *J Phys Ther Sci*. 2015;27:2275–2278.
14. Kim JH, So KH, Bae YR, et al. A comparison of flexi-bar and general lumbar stabilizing exercise effects on muscle activity and fatigue. *J Phys Ther Sci*. 2014;26:229–233.
15. Lee SJ, Kim YN, Lee DK. The effect of flexi-bar exercise with vibration on trunk muscle thickness and balance in university students in their twenties. *J Phys Ther Sci*. 2016;28:1298–1302.
16. Chung SH, You YY, Lee HJ, et al. Effects of stabilization exercise using flexi-bar on functional disability and transverse abdominis thickness in patients with chronic low back pain. *J Phys Ther Sci*. 2018;30:400–404.
17. Phanpheng Y, Hiruntrakul A. Effects of flexi bar training model to health-related physical fitness in overweight adults. *J Phys Ther Sci*. 2020;32: 489–495.
18. Lee DK, Kim EK. Effects of active vibration exercise on trunk muscle activity, balance, and activities of daily living in patients with chronic stroke. *J Kor Phys Ther.* 2018;30:146–150.
19. American College of Sports Medicine, Chodzko-Zajko WJ, Proctor DN, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc*. 2009;41:1510–1530.
20. Ministry of Health and Welfare. *Health Exercises for the Elderly.* Available at https://www.hpa.gov.tw/Video/RecommendVideo.aspx?nodeid=851&vid=3182017. Accessed February 2, 2021. [In Chinese]
21. Tsay SF, Chen SC, Lu SJ, et al. The policy and practice of preventive care for the elderly. *Hu Li Za Zhi.* 2018;65:13–19.
22. Rikli RE, Jones CJ. *Senior Fitness Test Manual*. 2nd ed. Champaign, USA: Human Kinetics; 2013.
23. Rikli RE, Jones CJ. Development and validation of a functional fitness test for community-residing older adults. *J Aging Phys Act.* 1999;7:129–161.
24. Kuorinka I, Jonsson B, Kilbom A, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon.* 1987;

18:233–237.
25. Crawford JO. The Nordic musculoskeletal questionnaire. *Occup Med (Lond).* 2007;57:300–301.
26. Malloy-McFall JY. *Multi-Component Exercise Program in a Life-Care Community: For Adults 80 Years of Age and Older*. PhD thesis. Kent, USA: Kent State University; 2010. Available at http://rave.ohiolink.edu/etdc/view?acc_num=kent1290030262. Accessed March 11, 2021.
27. Bird M, Hill K, Ball M, et al. The long-term benefits of a multi-component exercise intervention to balance and mobility in healthy older adults. *Arch Gerontol Geriatr.* 2011;52:211–216.
28. McArdle WD, Katch FI, Katch VL. *Exercise physiology: nutrition, energy, and human performance*. 7th ed. Baltimore, USA: Lippincott Williams & Wilkins; 2010.
29. Jacobs PL, Burns P. Acute enhancement of lower-extremity dynamic strength and flexibility with whole-body vibration. *J Strength Cond Res.* 2009;23:51–57.
30. Torvinen S, Sievänen H, Järvinen T, et al. Effect of 4-min vertical whole body vibration on muscle performance and body balance: a randomized cross-over study. *Int J Sports Med.* 2002;23:374–379.
31. Lee DK, Kim YN, Park CB, et al. The effect of actively induced vibration using shoulder joint on pain and dysfunction in patients with low back pain. *J Phys Ther Sci*. 2018;30:23–26.
32. Hurley L. *Strengthening Transversus Abdominis in Subjects with a History of Lower Back Pain and Asymptomatic Individuals: The FLEXI-BAR V's Stabilization Training By*. 2007. Available at http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=3E44462B0C442298DC2C8025460F54F6?doi=10.1.1.629.4517&rep=rep1&type=pdf. Accessed March 11, 2021.
33. Mendell LM. Constructing and deconstructing the gate theory of pain. *Pain.* 2014;155:210–216.
34. Kukuljan S, Nowson CA, Bass SL, et al. Effects of a multi-component exercise program and calcium–vitamin-D3-fortified milk on bone mineral density in older men: a randomised controlled trial. *Osteoporos Int.* 2009;20:1241–1251.
35. Turcotte AF, Kukuljan S, Dalla Via J, et al. Changes in spinal bone density, back muscle size, and visceral adipose tissue and their interaction following a multi-component exercise program in older men: Secondary analysis of an 18-month randomized controlled trial. *Osteoporos Int.* 2020;31:2025–2035.
36. Purepong N, Jitvimonrat A, Boonyong S, et al. Effect of flexibility exercise on lumbar angle: a study among non-specific low back pain patients. *J Bodyw Mov Ther.* 2012;16:236–243.
37. Lee DK, Han JW. Effects of active vibration exercise using a Flexi-Bar on balance and gait in patients with chronic stroke. *J Phys Ther Sci*. 2018;30:832–834.
38. Sá-Caputo Dda C, Ronikeili-Costa P, Carvalho-Lima RP, et al. Whole body vibration exercises and the improvement of the flexibility in patient with metabolic syndrome. *Rehabil Res Pract.* 2014;2014:628518.
39. Sa-Caputo DC, Paineiras-Domingos LL, Oliveira R, et al. Acute effects of whole-body vibration on the pain level, flexibility, and cardiovascular responses in individuals with metabolic syndrome. *Dose Response.* 2018;16:1559325818802139.
40. Liu C, Lee YC, Lin YL, et al. Factors associated with anxiety and quality of life of the Wuhan populace during the COVID-19 pandemic. *Stress Health.* 2021;37:887–897.
41. Pakpour AH, Liu CH, Hou WL, et al. Comparing fear of COVID-19 and preventive COVID-19 infection behaviors between Iranian and Taiwanese older people: early reaction may be a key. *Front Public Health.* 2021;9:740333.
42. Ghoncheh KA, Liu CH, Lin CY, et al. Fear of COVID-19 and religious coping mediate the associations between religiosity and distress among older adults. *Health Promot Perspect.* 2021;11:316–322.
43. Lin CY, Li YP, Lin SI, et al. Measurement equivalence across gender and education in the WHOQOL-BREF for community-dwelling elderly Taiwanese. *Int Psychogeriatr.* 2016;28:1375–1382.
44. Marufkhani V, Mohammadi F, Mirzadeh M, et al. Leisure activity engagement as a predictor for quality of life in community-Dwelling older adults. *Asian J Soc Health Behav.* 2021;4:2–7.