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RESEARCH ARTICLE

Multi-Component Exercise Programme for Sarcopenia and Frailty Population - An Observational Study

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Abstract

Objectives: To find out the effect of multicomponent exercise programme on sarcopenia and frailty in elderly population. **Methods:** This was an observational study. The elderly population with an age group of >60 years residing in villages within 10–15 km of Sumandeep Vidyapeeth, Vadodara, India, was considered in the study. The study population consisted of 205 participants who were diagnosed with sarcopenia and frailty during phase 1 of the study. The study was conducted from August 2022 to May 2023. The participants were placed on a multicomponent exercise programme that included resistance training exercises, balance exercises, flexibility exercises, and endurance exercises. Grip strength, muscle mass, appendicular skeletal muscle mass (ASM), skeletal muscle index (SMI), calf circumference (CC), gait speed, and frailty were assessed at the end of 4 weeks, 8 weeks, and 12 weeks. Microsoft Excel and STATA-IC statistical software, version 13, were used to analyse the data. **Findings:** A total of 59 participants adhered to exercises for 12 weeks. Mauchly's sphericity test showed a statistically significant change in ASM and SMI (P = 0.001). In the subject effects over a duration of 4 to 12 weeks, there was no statistically significant difference found in grip strength (p = 0.257), right CC (p = 0.114), ASM (p = 0.109), SMI (p = 0.052), and gait speed (p = 0.641). At the end of 12 weeks, there was a reduction in the status of frailty 1.7% "frail," 6% "pre-frail," and 91.5% "no frail" as compared to 3.4%, 8.5%, and 88.1%, respectively at 4 weeks. **Conclusion:** In the present study, multicomponent exercise programme had no statistically significant effect on sarcopenia (grip strength, muscle mass, or gait speed) according to the follow-up data from weeks 4 to 12. Despite this, a 12-week exercise programme improved the frailty status. **Novelty:** This study is one of its kind where elderly population having Sarcopenia and Frailty were given exercise programme for

12-weeks of duration at their doorsteps in the community.

Keywords: Sarcopenia; Frailty; Exercise; Older adults; Multicomponent Exercise

1 Introduction

Sarcopenia is a condition characterised by the progressive loss of muscle mass, strength, and functional capacity that occurs with ageing[1]. India has 104 million elderly people (aged around 60 years and older), according to the 2011 population census. In 2016, a multi-continental study found 17.5% prevalence[2] while 14.2% prevalence of sarcopenia was found in India[3].Sarcopenia leads to negative health effects in the elderly population, such as falls, frailty, physical inactivity, limitations in activity participation, lower quality of life, and an increased risk of premature death[4]. There are various criteria to assess sarcopenia and frailty, such as those of the European Working Group for Sarcopenia in Older People (EWGSOP) and the Asian Working Group for Sarcopenia (AWGS), which have assessment parameters such as muscle strength (grip strength), muscle mass, appendicular skeletal muscle mass (ASM), skeletal muscle index (SMI), and physical performance (gait speed), with slight variations in the cutoff values. Exercise is medicine, and the prescription of exercises should be tailored to the individual and controlled in the same way as any other medical treatment, with a focus on the frequency, duration, and intensity, as well as practical implementation strategies[4,5]. Exercise training minimises frailty in older adults by suppressing muscle inflammation and boosting anabolism, which results in an increase in the rate of muscle protein synthesis[6]. Exercise intervention has been found to be the most evident treatment option for sarcopenia, and it has a beneficial effect on muscle mass, grip strength, and gait speed[7]. Recent systematic reviews have suggested various nonpharmacological treatments for sarcopenia and have also suggested in terms of nutritional status, degree of physical frailty, and exercise training mode[8].

In sarcopenia, regular exercise, particularly resistance exercise, can provide numerous benefits, including increased muscle mass and strength, improved functional performance, reduced risk of chronic diseases, improved mental health, increased energy and vitality, improved metabolism, and maintenance of bone density[7]. The majority of these studies were comprised either of resistance training exclusively or a combination of aerobic training, resistance, and balance training, with the degree of exercise (including aerobic and resistance-based exercise) ranging from low to moderate[9].

Exercise has positive effects on improving muscular strength and functional ability, especially during the three-month duration of an exercise protocol[10]. The available literature also supports that home-based exercise programmes had a beneficial effect over a long period of time once patients were given their commitment regarding exercises. Balance exercises can be an important component of exercise interventions for individuals with sarcopenia, as they can help improve balance and prevent falls, fall-related injuries, and functional mobility[11]. Based on previous evidence, multicomponent exercise programmes include resistance training, gait retraining, balance exercises, task-specific training, occupational therapy, etc.[12]. To prevent the onset of sarcopenia in older adults and in people with frailty and pre-frailty, a multicomponent exercise programme can be used[13].Multicomponent exercise training, including resistance exercises (for 2 weeks), balance training, and aerobic activities at moderate intensity for at least 3 times a week and 30 to 45 minutes per session for 3 to 5 months, has shown an improvement in functional ability in older adults with sarcopenia and frailty[10].

In India, there is least attention given to exercise in the elderly population, and performing daily activities is considered sufficient for maintaining physical health[14]. Moreover, there is scant literature on sarcopenia and frailty in the elderly population in

India. Hence, the aim of the present study is to see the effect of a multicomponent exercise programme on sarcopenia and frailty in the elderly population.

2 Methodology

The participants (n = 205) who were found to have sarcopenia and frailty in phase I of the study comprised the study population. The phase II of the study has been approved by the Institutional Ethics Committee No. SVIEC/ON/Phys/RP/21005, and all the participants were further informed about the phase II of the study, and their consent was obtained. The duration of the study was from August 2022 to May 2023. Out of 205 participants who were diagnosed with sarcopenia and frailty, 116 (56.58%) gave their consent to participate in phase II of the study, and only 59 (50.86%, out of 116 participants who gave their consent) completed the exercise protocol for 12 weeks. The consolidated standards of reporting trial (CONSORT) flow chart of the number of participants enrolled, participants who adhered to the protocol, and drop-outs is shown in Figure 1.

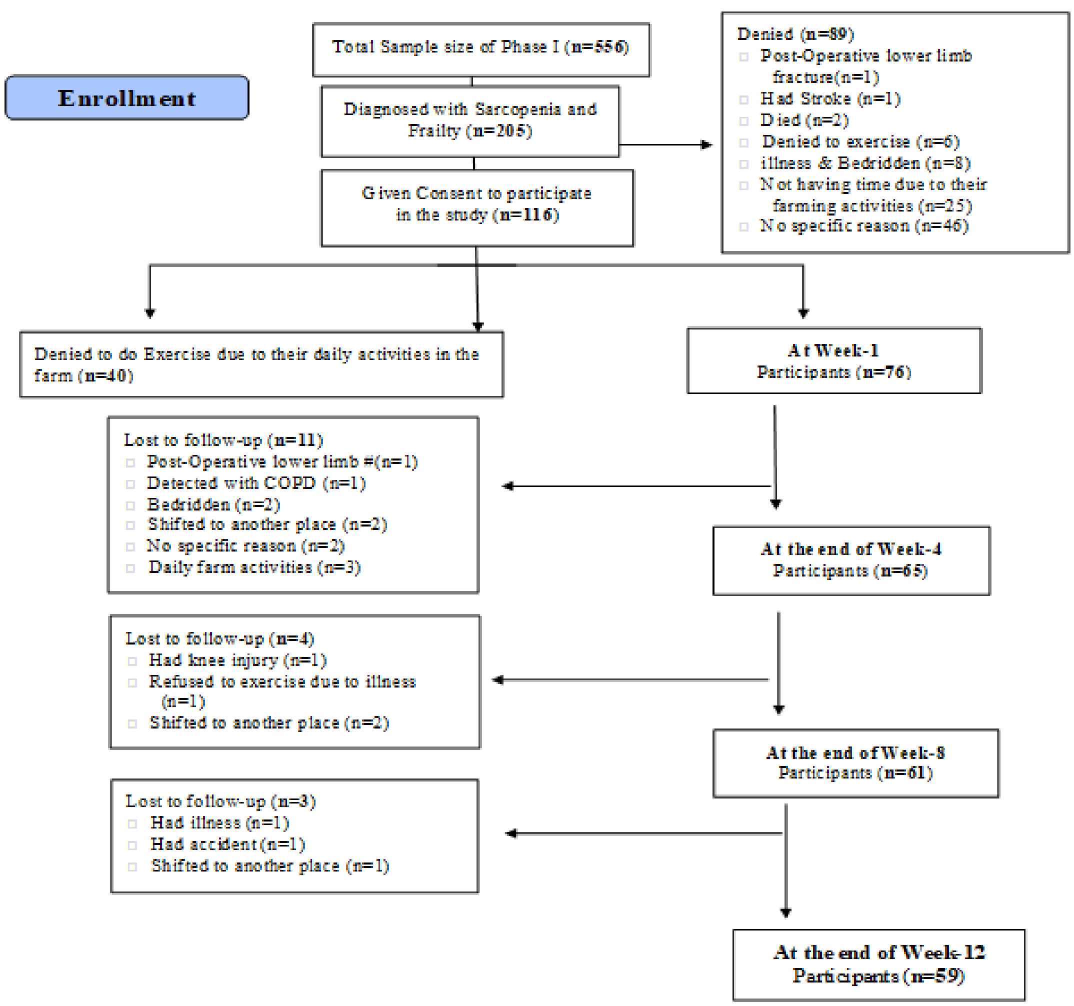

Fig 1. Consolidated Standards of Reporting Trials (CONSORT) Flow Chart

The total duration of the exercise programme was 12 weeks. The exercise protocol included resisted training exercises, balance training exercises, flexibility training, and endurance training, where resisted training exercises and balance exercises were given alternately three days a week and flexibility and endurance exercises were given alternately three days a week, other than the days when resisted and balance exercises were given. Follow up time period was 4^{th},8^{th} and 12^{th} week. Resisted exercises, as shown in Figures 2 and 3, and balance exercises, as shown in Figure 4.

Fig 2. High sitting knee extension Exercise

Fig 3. Standing knee curls (Hamstring)

Fig 4. Tandem standing/Toe Heel standing

The multicomponent exercise programme involved an upper and lower limb progressive resistance training program for 2 to 3 times per week, with 3 sets of 8 to 12 repetitions at an intensity that started with 20%-30% of 1RM and progressed to 80% of 1RM three times per week. Balance training (static, dynamic, and proactive training) was given three times per week. In the endurance training, participants were asked to walk for 15 to 30 minutes three times per week with moderate intensity (11 to 13 points on the Borg scale). The participants were asked to maintain a compliance log or daily log of activities performed. All the exercises were given on an individual basis at the participants doorsteps, as there was no provision for a common place in the villages where exercises could have been given in groups to save time as well as increase motivation among the participants.

Grip strength, muscle mass, appendicular skeletal muscle mass, skeletal muscle index, calf circumference, gait speed, and frailty were assessed at the end of 4 weeks, 8 weeks, and 12 weeks. A Jamar Plus+ electronic hand-held dynamometer was used to measure grip strength (both sides and the average of three trials were taken for interpretation), an Omron Body Composition Analyzer was used to assess the skeletal muscle mass, and appendicular skeletal muscle mass was calculated using the Lee formula, i.e., ASM = (0.244$\times$body weight-kg) +(6.6$\times$gender) -(0.098$\times$age) + (race-3.3)[15]. Microsoft Excel was used to compute the skeletal muscle index (SMI) using the ASM/height (m^2) formula. Calf circumference (having a cut-off value of 34cm for males and 33cm for females)[16]. Calf circumference was measured using a flexible measuring tape in standing posture. Gait speed was measured by a 4-metre walk test, and the average of two trials was taken. Frailty was assessed using the Study of Osteoporotic Fractures (SOF) frailty index. The data were analysed using STATA-IC statistical software version 13 along with Microsoft Excel. At the end of the 12-week exercise programme, subjects were also asked to share their experiences with respect to the changes they observed in their strength, ability to carry out their daily functional activities, fatigue levels, overall quality of life, etc.

3 Results

There were 59 participants with a mean age of 68.66 $\pm$ 8.066 years who performed exercises for 12 weeks. The demographic details of the participants are shown in Table 1.

All the parameters, such as grip strength, skeletal muscle mass, appendicular skeletal muscle mass, calf circumference, gait speed, and SOF index, were analysed at follow-up periods, i.e., at the end of the 4th week, 8th week, and 12th week, using the general linear model (repeated measures ANOVA). The comparison of right grip strength, left grip strength, ASM, SMI, right calf circumference, left calf circumference, and gait speed from 4 to 12 weeks is shown in Table 2.

Mauchly's sphericity test shows no statistically significant result in right grip strength, left grip strength, right calf circumference, or left calf circumference (p-value >0.05), hence the variances of the response variable are the same at each time point, but show statistically significant results in ASM and SMI, which infer that the sphericity is assumed and hence the

Table 1. Demographic Details of all the participants (n=59)

	Number of Participants	Percentage
Sarcopenic	205	37
SOF Frailty Index		
Frail	31	5.6
Pre-Frail	107	19.2
No-Frail	418	75.2
Gender		
Male	5	8.5
Female	54	91.5
Hand Dominance		
Right	57	96.6
Left	2	3.4

Table 2. Comparison of parameters (Right Grip Strength, Left Grip Strength, ASM, SMI, Right calf circumference, Left Calf circumference and Gait speed) from 4 to 12 weeks

Parameters	N	Mean	Std. Deviation
Right Grip Strength			
4 weeks	59	12.24	3.29
8 weeks	59	11.86	3.82
12 weeks	59	12.24	3.59
Left Grip Strength			
4 weeks	59	11.77	3.56
8 weeks	59	11.51	3.83
12 weeks	59	11.40	3.57
Appendicular Skeletal Muscle mass (ASM)			
4 weeks	59	10.48	3.39
8 weeks	59	10.63	3.28
12 weeks	59	10.66	3.28
Skeletal Muscle Index (SMI)			
4 weeks	59	4.77	1.19
8 weeks	59	4.86	1.10
12 weeks	59	4.86	1.12
Calf Circumference Right (CC_R)			
4 weeks	59	26.33	2.20
8 weeks	59	26.24	2.27
12 weeks	59	26.54	2.36
Calf Circumference Left (CC_L)			
4 weeks	59	26.16	2.21
8 weeks	59	26.23	2.26
12 weeks	59	26.51	2.33
Gait			
4 weeks	59	0.86	0.25
8 weeks	59	0.85	0.25
12 weeks	59	0.84	0.23

ASM: Appendicular Skeletal Muscle mass, SMI: Skeletal Muscle Index, CC_R: Calf Circumference Right, CC_L: Calf Circumference Left variances of the response variable are not the same at each time point shown in Table 3.

Table 3. Mauchly's Test of Sphericity

Mauchly's Test of Sphericity							
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	P-value	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Right Grip Strength	.986	.822	2	.663	.986	1.000	.500
Left Grip Strength	.964	2.075	2	.354	.965	.998	.500
ASM	.843	9.725	2	.008	.864	.889	.500
SMI	.781	14.112	2	.001	.820	.841	.500
CC_R	.935	3.835	2	.147	.939	.969	.500
CC_L	.914	5.128	2	.077	.921	.950	.500
Gait speed	.919	4.830	2	.089	.925	.954	.500

Ho : Variances of the response variable is same at each time point.
ASM: Appendicular Skeletal Muscle mass, SMI: Skeletal Muscle Index, CC_R: Calf Circumference Right, CC_L: Calf Circumference Left.

There was no statistically significant change seen in right-hand grip strength, left-hand grip strength, ASM, SMI, right calf circumference, or gait speed during 4 to 12 weeks, while a statistically significant change was seen in left calf circumference during 4 to 12 weeks. This is shown in Table 4.

Table 4. Tests of Within-Subjects Effects

Tests of Within-Subjects Effects						
Source		Type III Sum of Squares	Df	Mean Square	F-value	P-value
Right Grip Strength	Sphericity Assumed	5.771	2	2.886	1.374	.257
	Greenhouse-Geisser	5.771	1.972	2.927	1.374	.257
	Huynh-Feldt	5.771	2.000	2.886	1.374	.257
	Lower-bound	5.771	1.000	5.771	1.374	.246
Left Grip Strength	Sphericity Assumed	4.278	2	2.139	.925	.400
	Greenhouse-Geisser	4.278	1.931	2.216	.925	.397
	Huynh-Feldt	4.278	1.996	2.143	.925	.399
	Lower-bound	4.278	1.000	4.278	.925	.340
ASM	Sphericity Assumed	1.066	2	.533	2.258	.109
	Greenhouse-Geisser	1.066	1.729	.617	2.258	.117
	Huynh-Feldt	1.066	1.777	.600	2.258	.116
	Lower-bound	1.066	1.000	1.066	2.258	.138
SMI	Sphericity Assumed	.302	2	.151	3.023	.052
	Greenhouse-Geisser	.302	1.640	.184	3.023	.063
	Huynh-Feldt	.302	1.682	.180	3.023	.062
	Lower-bound	.302	1.000	.302	3.023	.087
CC_R	Sphericity Assumed	2.754	2	1.377	2.211	.114
	Greenhouse-Geisser	2.754	1.878	1.467	2.211	.118
	Huynh-Feldt	2.754	1.938	1.421	2.211	.116
	Lower-bound	2.754	1.000	2.754	2.211	.142
CC_L	Sphericity Assumed	4.003	2	2.001	3.491	0.034
	Greenhouse-Geisser	4.003	1.842	2.174	3.491	.038
	Huynh-Feldt	4.003	1.899	2.108	3.491	.036
	Lower-bound	4.003	1.000	4.003	3.491	.067
Gait	Sphericity Assumed	.012	2	.006	.446	0641
	Greenhouse-Geisser	.012	1.850	.007	.446	.626
	Huynh-Feldt	.012	1.908	.006	.446	.632
	Lower-bound	.012	1.000	.012	.446	.507

ASM: Appendicular Skeletal Muscle mass, SMI: Skeletal Muscle Index, CC_R: Calf Circumference Right, CC_L: Calf Circumference Left.

Among 59 participants after completing 12 weeks, 1.7% (n=1) participants were found to be frail, 6.8% (n=4) were found to be "pre-frail" and 91.5% (n=54) participants were "no frail", as compared to 3.4%, 8.5%, and 88.1%, respectively, at 4 weeks, as shown inFigure 5.

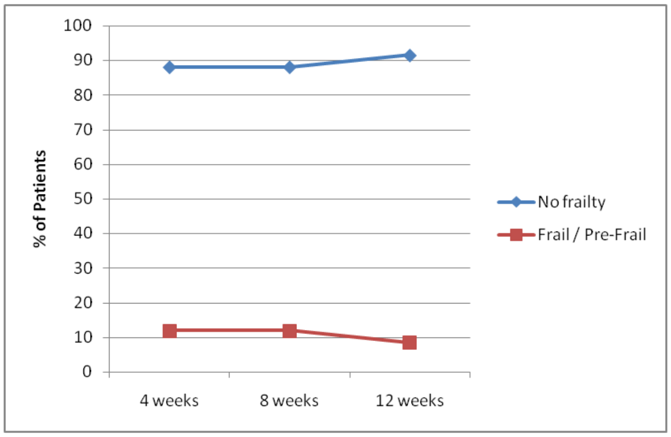

Fig 5. SOF of patients during follow-up (n=59)

At the end of the 12-week multi-component exercise programme, the participants were asked about their experience. Their experiences were recorded and transcribed into English, and various themes were retrieved, as seen in Table 5.

Table 5. Participants' Quotations & Themes (Qualitative Analysis)

Participants' Quotations	Themes
"Feels good" "Feels better" "Feels healthy" "Feels difference" "Feels energized"	Affective/ Feel a change
"Reduced shortness of breath" "Reduced Pain" "Reduced tingling sensation" "Reduced leg stumbling/thumping"	Reduction in Impairments
"Increased ability to work" "Reduced difficulty in household chores" "Takes less time to get up from floor" "Can sweep the floor" "Can sit for longer time" "Can move around easily" "Can carry more/heavy weights" "Can easily do light weight work"	Improvement in Activity
"Improvement in performing farming activities"	Improvement in Participation

4 Discussion

The aim of the study was to see the effect of multi-component exercises on sarcopenia and frailty in the elderly population. The response rate of the participants who gave consent and participated in the study was 56.58% (n = 116), which is quite acceptable, but out of which only 50% (n = 59) of the participants completed the study until 12 weeks, in spite of giving the exercises on an individual basis at their doorsteps. This is one of its kind, where elderly individuals with sarcopenia and frailty were given exercise programmes at their doorsteps on a one-to-one basis. The exercise programme was individualised and given for twelve weeks. This study has also paved the way for a long-term, regular, or continuous exercise programme, not just limited to 12 weeks.

Various reasons documented in the present study for non-consent or non-adherence to the study protocol were a busy daily schedule on the farm, a change of place, or any medical condition during the tenure such as knee injuries, fractures, pulmonary conditions, stroke, or mortality. Various reasons cited in the literature pertaining to non-adherence to an exercise programme were lack of time due to social, work, or family responsibilities, lack of interest, and being reluctant to change the daily routine(17), (18).

In this study, the majority of the participants found to have sarcopenia and frailty were females, and we have also found a higher prevalence of sarcopenia in females. Previous research had revealed several genders-specific clinical risk factors such as age, height, weight, body mass index, waist circumference, skeletal muscle index, and fasting glucose and insulin levels. Females skeletal muscle mass and bone density levels alter with age due to hormonal changes, increasing the chance of developing sarcopenia(19).

With age, there is a decline in grip strength, appendicular skeletal muscle mass, skeletal muscle index, calf circumference, gait speed, and the status of frailty. The decline rate of grip strength was associated with risk factors like reduction of all body skeletal muscle mass, activity level, and lifestyle [20]. Grip strength is a biomarker in older adults [20]. It is measured by the Jamar hand dynamometer, which is widely cited in the literature and accepted as the gold standard [21].

However, the grip strength of our population was within the low range and remained at that level even after the exercises. The various reasons cited for the low grip strength are C-terminal Agrin Fragment (CAF), environmental factors, activities of daily living, disease-specific mortality, bone mass, fractures, cognition, depression, sleep, falls, disease-specific mortality, etc. [22,23]. After the age of 30, muscle mass declines by about 3–8% every decade, and as the age goes above 60, the rate of decline is much [24]. The current study observed no statistically significant change in SMI and ASM from week 4 to week 12 of the exercise programme. Similar to it, prior exercise intervention studies had reported minimal to no significant change in the skeletal muscle index and appendicular skeletal muscle [25].

Gait speed is the functional outcome measured to find out participants physical functional level, and it has an association with the sensory and motor systems. Changes in sensory and motor systems with ageing lead to balance problems as well as a decrease in gait speed [26]. In this study, no statistically significant change was seen in the gait speed from week 4 to week 12, similar to the previous study, which reported no significant change in gait speed with exercises in sarcopenia and older adults, but found significant results with exercise and nutritional treatment of individuals [27].

Frailty is associated with a number of biological variables, such as a reduction in muscle mass and a loss of balance driven by the biological processes of ageing [28]. In the present study, there was a reduction in the number of participants falling under "Frail" and "Pre-Frail" and increase in the number of participants under "No Frailty", similar to Previous studies on sarcopenia and frailty also found a positive effect on frailty status after multicomponent exercises in sarcopenia and frailty [11].

Though there was no statistically significant effect of exercises observed on sarcopenia and frailty in the elderly population, the point to be taken into consideration is that at least all the parameters assessed were maintained and there was no decline while exercises were administered. At the same time, an informal qualitative analysis showed better subjective well-being, increased ability to perform functional activities and household chores, getting up from the floor, carrying weights, walking ability, reduced fatigue, and shortness of breath.

These findings imply that, though there is clinical or subjective significance to the exercises observed, probably exercises of longer duration are required to see a statistically significant change in the parameters, such as grip strength, appendicular skeletal muscle mass (ASM), skeletal muscle index (SMI), calf circumference (CC), gait speed, and status of frailty. The study has been conducted in one locality or geographical area, and fewer participants gave consent or adhered to the exercise protocol; those may be some of the limitations of the study. In the future, strategies to increase the compliance of the participants with exercises can be sought either at their community or a nearby health center. A multidisciplinary study comprising a multicomponent exercise programme and nutritional guidance or other non-pharmacological measures can also be done.

5 Conclusion

The present study concludes that there was no statistically significant effect of a multicomponent exercise programme on sarcopenia (grip strength, muscle mass, and gait speed) during the follow-up period (from week 4 to week 12). However, there was a positive effect of the multicomponent exercise programme on the frailty status of the participants. Moreover, the qualitative interview did reveal the change after exercise in the form of a reduction in their impairment and an improvement in activities and participation.

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