Passive and active exercises are similarly effective in elderly nursing home residents

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Abstract. [Purpose] The aim of this study was to compare the efficacy of passive motion exercise and active motion exercise on functional fitness in elderly nursing home residents. [Subjects and Methods] Twenty-three (female 22 and male 1) nursing home residents (84.8±4.3 yr) volunteered for this study. They were divided into a passive motion exercise group (n=12) and an active motion exercise group (n=11) and performed 30-min sessions of training twice a week for 12 weeks. Functional fitness (Arm Curl, Chair Stand, Up & Go, Sit & Reach, Back Scratch, functional Reach, and 12-min Walk tests) was evaluated before and after the intervention. [Results] No significant baseline difference was noted between the groups in measured variables. Following the 12 week intervention, no significant interaction (group × time) was noted in functional fitness variables between the groups, except for the functional reach scores (active motion exercise 40%, passive motion exercise 9%). Significant improvement over time was noted in passive motion exercise group in Arm Curl (19%), Chair Stand (15%), Up & Go (6%), and 12-min Walk (12%) scores; and in the active motion exercise group in Arm Curl (14%), Chair Stand (19%), Up & Go (11%), functional Reach (40%) and 12-min Walk (13%) scores. The adherence rates in the passive and active motion exercise groups were 95.8% and 93.1% respectively. [Conclusion] Passive motion exercise and active motion exercise were found to be similarly effective for improving the functional fitness of elderly nursing home residents.
Key words: Nursing home-dwelling older adults, Active motion exercise, Passive motion exercise

INTRODUCTION

It is well documented that an inactive lifestyle, such as bed rest, in otherwise healthy individuals is associated with decreased physical function exacerbated by changes in body composition, that is, decreased muscle mass and increased fat mass[1]. A nursing home-based lifestyle is often sedentary, and it has been reported that frail older women residing in a nursing home experienced a significant progressive loss of muscle mass[2].

On the other hand, research over the past two decades clearly shows that regular exercise, that is, active motion exercise (AME), is effective for maintaining and promoting health, physical fitness, and functional independence in older adults, especially in terms of endurance, muscular strength, flexibility, and balance[3–5]. However, there are many older adults who have limitations in performing active exercises, especially weight-bearing exercises due to orthopedic conditions, poor musculoskeletal conditions, excess adiposity, poor balance, or simply age-associated sarcopenia[6–8]. Passive motion exercise (PME) may be an alternative mode of exercise for those elderly who cannot perform AME.

Machine-based PME was found to be beneficial in frail elderly users of a day care service[9] as well as in community-dwelling chronic stroke patients with spastic paralysis[10]. However, little information is available about PME in nursing home residents, and its efficacy has not been compared with that of AME. Therefore, the purpose of the current study was to compare the efficacy of PME with that of AME in a group of nursing home-dwelling elderly people.

SUBJECTS AND METHODS

In response to a public call for participation (leaflets and oral) through proper channels, 23 residents (mean age 85.3 yr; 80 to 98 yr, 22 female and 1 male) of a nursing home in Yokkaichi City, Mie Prefecture, Japan, volunteered to participate in this study. The average nursing home residence period for these people was 8.2 years (1.9 years to 18.4 years). The participants (Table 1) were then divided into a PME group

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and an AME group. The nursing home where the participants were residing assists only in instrumental activities of daily living (ADL)[11], and all participants were able to walk indoors by themselves. No assistance was needed for these people while eating, dressing, or taking a bath. However, assistance was needed in preparing food, preparing a bathtub, preparing a shower room etc. None of them were suffering from uncontrolled hypertension, congestive heart failure, untreated ischemic heart disease, or untreated arrhythmia. None had any restrictions advised by their attending physician with regard to physical exercise performance.

The ethics committee of the Suzuka University of Medical Science approved the study (Approval No. 139). All participants received written and oral instructions of the study, and each gave written informed consent before participation.

PME was performed in 30-min sessions twice a week for 12 weeks with four different types of passive exercise machines (Motorcise, Combi Wellness Corporation, Tokyo, Japan). Each type of PME was performed on the respective machine for five minutes. Five minutes of warm-up and five minutes of cooldown exercises were performed before and after each session. The passive exercise machines and exercise contents are shown in Table 2. Exercises were performed on each machine for five continuous minutes, resulting in a total of 20 minutes of PME. The AME was designed based on Takeshima's home-based resistance exercise program[12], with minor modification to make it suitable for nursing home-dwelling older people. The AME was performed in 30-min sessions twice a week for 12 weeks with elastic bands (Thera-Band, The Hygenic Corporation, Akron, OH, USA). Band-based AME was performed for 20 minutes each day. Five minutes of warm-up and five minutes of cooldown exercises were performed before and after each session. In order to train all major muscle groups, band-based AME was prescribed as a combination of 3 upper body exercises and 3 lower body exercises (Table 3). Each type of exercise was performed for 1 set of 10 repetitions[13] for a total period of five minutes per session. The band-based AME intensity was targeted at 13 on the Borg Rating of Perceived Exertion Scale[14]. The participants started with the red Thera-Band (band of lower resistance), and some of them then progressed to the green Thera-Band (band of higher resistance) during the program.

Body height, mass, BMI, and functional fitness were measured before and after the 12-wk exercise interventions in all participants. All measurements were completed within one week before and one week after the interventions.

A battery of field tests was used to assess the components of functional fitness having good test-retest reliability and validity[15–18].

Upper-body strength was assessed using the 30-sec Arm Curl Test (AC)[16], in which the participants flexed and extended the elbow of the dominant hand, lifting a weight (men, 8-pound [3.6 kg] dumbbell; women, 5-pound [2.3 kg] dumbbell) through the complete range of motion, as many times as possible in 30 sec (score=number of repetitions). A practice trial of one or two repetitions was given, followed by two test trials, with the best performance used for analysis.

Lower-body strength was assessed using the 30-sec Chair Stand Test (CS)[16], in which the participants rose to

Table 1. Baseline characteristics of participants

	PME (n=12)	AME (n=11)
Age (yrs)	83.7±4.2	86.0±4.2
Height (cm)	149.2±6.5	149.7±4.0
Body mass (kg)	49.0±7.7	52.4±6.1
BMI (kg/m^2)	22.0±2.5	23.4±2.5
Arm Curl (times/30 sec)	16.0±4.0	17.6±4.2
Chair Stand (times/30 sec)	12.3±3.5	13.0±2.5
Up and Go (sec)	10.3±7.2	8.2±1.9
Sit and Reach (cm)	4.0±6.0	5.2±12.3
Back Scratch (cm)	−12.8±12.1	−10.4±11.6
Functional Reach (cm)	19.3±6.5	15.9±5.4
12-min walk distance (m)	505±209	646±106

Mean ± SD. PME: passive motion exercise; AME: active motion exercise; BMI: body mass index. No test variable was significantly different between the groups (p<0.05).

a full standing position from a chair and then returned to a fully seated position, and continued to complete as many full stands as possible in 30 seconds (score=number of stands). A practice trial of one or two repetitions was given, followed by two test trials, with the best performance used for analysis.

Balance and agility were assessed using the 8-foot Up and Go Test (UG)[16] and Functional Reach Test (FR)[15]. To perform the UG, the participants stood from a fully seated chair, walked as quickly as possible around a cone placed 8 feet (2.44 m) ahead of the chair, and returned to a fully seated position on the chair. The test was a timed test, and the best performance time in the test trials was recorded in tenths of a second. The participants practiced by walking through the test one time and then were timed during two test trials, with the best performance time used for analysis. To perform the FR, the participants stood with their feet together and both arms raised horizontally in front of them. They held the 0 centimeter level on the functional reach scale and then leaned forward, moving the hands forward along the scale as far possible without losing their balance (score (cm)=maximal distance the participant could reach forward beyond arms' length). A practice trial of one or two times was given, followed by two test trials, with the best performance used for analysis.

Upper-body flexibility was assessed using the Back Scratch Test (BS)[16], in which the participants placed their preferred hand behind the shoulder on the same side and the other hand behind the back, reaching up in an attempt to touch or overlap the extended middle fingers of both hands. The score was the number of centimeters the middle fingers were short of touching (negative score) or overlapped each other (positive score). A practice trial of one or two times was given, followed by two test trials, with the best performance used for analysis.

Lower-body flexibility was assessed using the Chair Sit and Reach Test (SR)[16], in which the participants sat on a chair and then slowly reached forward, sliding their hands down an extended leg in an attempt to touch their toes (without bending the extended knee). The score was the number of centimeters short of reaching the toes (negative score) or

Table 2. Passive motion exercise (PME) machines and performed exercises

Machine	Contents
1. Chest & Step	Stepping exercise of lower limbs and simultaneous upper limb movements that simulate swinging exercise for the upper limbs during walking or jogging.
2. Shoulder & Leg Press	Simultaneous upward shoulder push-pull and leg press.
3. Trunk & Twist	Trunk rotation with the aim of thoraco-lumbo-sacral joint mobilization.
4. Fly & Abduction	Simultaneous abduction-adduction movements of shoulder joints and hip joints as if the person is flying like a bird.

Table 3. Active motion exercise (AME)

	Exercise	Contents	Repetition
1	Double arm pull-back	The elastic band is held with both hands horizontally in front of the chest in an elbow-extended position. The band is pulled back over the course of 3 to 4 seconds to simulate the breaststroke in swimming. The original position is then returned to over the course of 2 to 3 seconds.	10
2	Arm curl	First, the band is fixed and held tight under the foot, and then the other end of the band is held by the hand on the same side while resting the hand on the thigh on that side. Then the elbow is slowly bent over the course of 3 to 4 seconds to perform a full arm curl. After that, the starting position is returned to over the course of 2 to 3 seconds. This constitutes one repetition.	10
3	Arm extension	The band is held using both hands. One hand is placed on the opposite shoulder. The other hand is placed in a flexed position. Then the hand on the shoulder is slowly extended over the course of 3 to 4 seconds. The starting position is returned to over the course of 2 to 3 seconds. This constitutes one repetition.	10
4	Knee extension	The band is tied at ankle level to both legs. Both knees are at flexed in the starting position. One knee is then slowly extended over the course of 3 seconds while the other knee position remains unchanged to create resistance. The starting position is then slowly returned to, to complete one repetition. After completing the complete set, the exercise is performed for the other leg in the same way.	10
5	Ankle press	The band is held with both hands and is then stepped on by a leg in such a way that the heel of the foot makes contact with the ground but the toes are bent upward a little. Then the band is pressed slowly over the course of 3 to 4 seconds as if pushing a car's accelerator. The starting position is returned to over the course of 2 to 3 seconds. This constitutes one repetition. After completing the complete set, the exercise is performed for the toes on the other foot in the same way.	10
6	Toe lift	The band is wrapped around the distal foot including toes of one leg and then pulled diagonally to create resistance. Then the tensed band is stepped on with the other foot. After that, the toe of the band-wrapped foot is raised against the resistance over the course of 3 to 4 seconds. The starting position is returned to over the course of 2 to 3 seconds. This constitutes one repetition. After completing the complete set, the exercise is performed for the toes on the other foot in the same way.	10

All exercises were performed in a seated position. The toe lift and ankle press were performed in bare feet.

reaching beyond the toes (positive score). A practice trial of one or two times was given, followed by two test trials, with the best performance used for analysis.

Cardiorespiratory fitness was assessed by performing the 12-minute Walk Test (12-MW) which assessed the maximum distance walked in 12 minutes around a 60-meter rectangular course marked into 5-meter segments[19, 20]. The score was the total number of meters walked in 12 minutes.

Unpaired t-tests were used for the comparison of groups before the exercise intervention. The effects of exercises were studied with repeated measures analysis of variance (ANOVA). The significance level was set at $p < 0.05$.

RESULTS

No significant differences at baseline were present between the PME group and AME group in any of the measured variables (Table 1).

All of the participants completed the training, and none suffered any injuries as a result of the training program. The adherence rates in the PME and AME groups were 95.8% and 93.1%, respectively.

No significant interaction (group × time) was noted in any of functional fitness variable in either group, except for the FR score (Table 4). The percentage of improvement in the FR score in the AME group was significantly larger than that in the PME group (40% vs. 9%).

In the PME group (time effect), significant improvement was noted in the AC (19%), CS (15%), UG (6%), and 12-MW (12%) scores, but no significant improvement was noted in the SR (20%), BS (11%) and FR (9%) scores (Table 4).

In the AME group (time effect), significant improvement was noted in the AC (14%), CS (19%), UG (11%), FR (40%) and 12-MW (13%) scores, but no significant improvement was noted in the SR (62%) and BS (10%) scores (Table 4).

Table 4. Effects of PME and AME on functional fitness

Variables/ Group	Pre-test Mean ± SD	Post-test Mean ± SD	Change (%)	Interaction (group×time)
Arm Curl (AC) (times/30 sec)				
PME	16.0±4.0	18.8±4.8*	18.9	F=0.499
AME	17.6±4.2	19.9±4.0*	14.1	
Chair Stand (CS) (times/30 sec)				
PME	12.3±3.5	13.9±3.5*	15.3	F=1.023
AME	13.1±2.6	15.4±2.1*	19.2	
Up and Go (UG) (sec)				
PME	10.3±7.2	9.6±6.9*	−6.1	F=0.181
AME	8.2±1.9	7.3±1.6*	−10.9	
Sit and Reach (SR) (cm)				
PME	4.0±6.0	5.4±6.5	−19.7	F=0.150
AME	5.2±12.3	5.8±10.1	−62.1	
Back Scratch (BS) (cm)				
PME	−12.8±12.1	−11.3±11.7	−10.7	F=1.374
AME	−10.4±11.6	−10.6±10.7	10.3	
Functional Reach (FR) (cm)				
PME	19.3±6.5	21.0±6.6*	9.4	F=9.851**
AME	15.9±5.4	21.3±5.1*	39.9	
12-min walk distance (12-MW) (m)				
PME	505±209	573±258*	12.2	F=0.224
AME	646±106	727±106*	13.2	

Mean ± SD. PME: passive motion exercise; AME: active motion exercise;
* p<0.05 within the group (time effect); ** p<0.05 between the groups (interaction)

DISCUSSION

The purpose of the current study was to compare the efficacies of PME and AME in a group of nursing home-dwelling elderly people. In general, passive physical exercises have been reported to be less effective compared with voluntary exercises in young adults[21]. However, in the current study, PME was found to have a similar effect on functional fitness, except functional reach, for these very old people.

A grave change associated with aging is the progressive decline in skeletal muscle mass, a downward spiral that may lead to decreased strength and functionality[8]. Therefore, the European Working Group on Sarcopenia in Older People has developed a definition and algorithm for sarcopenia, with sarcopenia being defined as the loss of muscle mass and strength that occurs with advancing age[8]. The current study did not measure muscle mass, but improvements in AC (19% in PME and 14% in AME) and CS (15% in PME and 19% in AME) scores in very old nursing home-dwelling people may be useful in preventing or at least controlling sarcopenia in these people. The improvements in the AC and CS scores in the current study were similar to, or better than the findings from other studies of community-dwelling and apparently healthy older adults, but the improvements in the current study were achieved with much lower exercise intensities, especially in the PME group. Takeshima et al.[22] found a 23% improvement in AC score and 21% improvement in

CS score following a 30-min elastic band-based resistance exercise program performed on land twice a week for 12 weeks. The average age of the exercisers (68.0±5.4 yr) in their study was much lower than those of the participants in the current study (PME 83.7±4.2 yr; AME 86.0±4.2 yr). Yamauchi et al.[20] found an 18% improvement in AC score and 6% improvement in CS score following a 26-min home-based exercise program performed 3 days/week for 12 weeks. The average age of the exercisers (69.2 ± 5.2 yr) in their study was much lower than those of the participants in the current study (PME 83.7±4.2 yr; AME 86.0±4.2 yr).

Fried et al.[23] developed a phenotypic definition of frailty based on readily identifiable physical aspects; three or more of the following characteristics support a frailty diagnosis: unintended weight loss, exhaustion, weakness, slow gait speed, and low physical activity. Based on the above frailty definition, not all of the nursing home residents were frail, but there was no doubt that all of them need assistance to complete their ADL. However, it is obvious that they had slower gait speeds and performed fewer ADL, as represented by their UG and 12-MW performances (Table 4).

Following a 26-min home-based exercise program (age 69.2±5.2 yr) performed 3 days a week for 12 weeks[20], the UG score improved by 14%, which is similar to the improvement in AME group (11%) in the current study and higher than the improvement in the PME group (6%) in the current study indicating that low-intensity AME and low-intensity PME are able to improve UG score in very old, frail elderly people.

The 12-MW score improved by 12% in the PME group and 13% in the AME group in the current study, which is similar to the improvement (16%) in 12-MW score following a 90-min aerobic training program consisting of walking outdoors 3 days per week for 12 weeks[4]. Although the participants of that study worked at higher intensity (70–80% of the participants' maximal heart rate) and were apparently healthy, their mean age of 71.6 ± 7.1 yr was quite lower than those of the participants in the current study (PME 83.7 ± 4.2 yr; AME 86.0 ± 4.2 yr). Thus, the gained benefit in 12-MW score in the current study might be due to the participants having a poor initial level of physical fitness.

Improvement in lower body flexibility (20% in the PME group and 62% in the AME group) and upper body flexibility (11% in the PME group and 10% in the AME group) was satisfactory. However, it has been reported that there is large individual variation in the age-related changes in flexibility[24]. Another study[25] reported similar results; in that study, older adults showed significant improvement in several functional fitness parameters but no improvement in trunk flexibility, which was measured by trunk anteroflexion in a sitting position with the knee extended after completion of a 12-week training program (twice a week).

Significant interaction (group × group) was noted only in the FR score, a measure of dynamic balance, in the current study. Therefore, effect of AME on dynamic balance seems to be superior to that of PME. The passive mode of training might be responsible for lesser improvement of balance. Further study is needed to overcome this limitation.

The improvements in all other measured variables except the FR score were similar in the two groups, with no signifi-

cant difference. At present there is no specific recommendation for exercise volume (e.g., kcal expenditure per week, step rate, etc.) for frail and/or nursing home residents[2], and as the improvements in most of the measured variables in the current study were similar for PME and AME, thus the PME could be an alternative preferred mode of exercise for very old people who cannot adhere to an AME program due to various reasons. Future studies should compare the dose-response relationship for muscle strength, especially for PME programs in elderly people.

Reports are available that describe the clinical benefits of passive exercises, for instance, passive exercise using a horseback riding machine improved insulin sensitivity and resting metabolism in diabetic patients[26], and passive leg movements enhanced the tissue oxygenation level in paretic muscles of chronic stroke patients[27]. From these reports, PME seems to be effective in clinical settings, but the mechanisms of how exercise produced these benefits were not clearly described in those studies. Therefore, further study is needed to explore the underlying mechanisms of these benefits.

The PME machines used in the current study were designed in such a way that passive exercise could be performed automatically while maintaining adequate physiological safety for the exerciser. They automatically stop moving when the user wishes to stop exercise; that is, they do not contract the target muscle group at all. All exercises were performed in a sitting position, which further ensured the training related safety of the PME.

Regular physical activity and/or exercises are recommended for all elderly people, but many of them do not like to do exercise on a regular basis. Thus, it is very important to develop a suitable exercise menu for very old people so that they will be able to adhere to the program safely. Recently, whole body vibration exercise was found to significantly improve balance and reduce fear of falling in older adults[28]. Attention should be given to ensuring safety, an easy mode of performing training, and a higher intensity when designing an exercise protocol for older adults. Indeed, an important aspect in performance of exercise is to have fun, and the mode of training should be enjoyable. Tarakci et al.[29] suggested that Wii-based balance therapy is effective for improving balance and walking function in children with cerebral palsy. Furthermore, studies are needed to identify adverse effects of training as well as how to increase motivation to perform exercises in frail older adults as well as in children. In conclusion, PME and AME were similarly effective in improving FF in very old people, and PME could be an alternative preferred mode of exercise for very old people who cannot adhere to an AME program due to various reasons.

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