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Research article

EFFECT OF HOME-BASED WELL-ROUNDED EXERCISE IN COMMUNITY-DWELLING OLDER ADULTS

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ABSTRACT
The purpose of this study was to assess the efficacy of a home-based well-rounded exercise program (WREP) in older adults. Forty sedentary community-dwelling older adults were randomly assigned to an exercise group (n = 23; aged 62-80 yr, average: 69.2 ± 5.2; 12 men and 11 women) or a control group (n = 17; aged 63-85 yr, average: 70.1 ± 6.6; 5 men and 12 women). The exercise group performed a 12-wk WREP which included aerobic exercise (walking) on about 3 days·wk^{-1} for 37 min·day^{-1}; elastic band-based resistance exercises for the major muscle groups on about 3 days·wk^{-1} for 26 min; and flexibility exercises (stretching) on about 4 days·wk^{-1} for 19 min·day^{-1}. General physical characteristics, functional strength (Arm Curl [AC], Chair Stand [CS]), dynamic balance and agility (Up & Go [UG]), flexibility (Back Scratch [BS], Sit & Reach [SR]), and endurance (12-min walk [12-MW]) were measured. Following the 12-wk home-based WREP, improvements were observed in AC, CS, UG, BS, SR and 12-MW for the exercise group but not for the control group. These results suggest that the home-based WREP can improve overall fitness in older adults.

KEY WORDS: Physical fitness, aerobic exercise, resistance exercise, flexibility exercise, adherence.

INTRODUCTION

It is estimated that the number of people aged 60 years and over throughout the world will increase from 606 million in 2000 to 1.9 billion by 2050 (United Nations, 2003). Thus, achieving long life and maintaining a high level of physical activity and vital function is an important challenge for society. It has been demonstrated that regular exercise 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 (American College of Sports Medicine [ACSM], 1998; Haskell, 1994; U.S. Department of Health and Human Services, 1996). In a recent study, Gill et al. (2004) found that functional decline and disability can be attenuated, if not prevented altogether, even in community dwelling frail older persons by providing home-based semi-supervised exercises called “prehabilitation”.

The ACSM (1998) suggests the use of a well-rounded exercise program (WREP) for overall fitness and health. Toraman and Sahin (2004) reported that supervised multicomponent training including walking, strengthening and flexibility exercises was effective in improving various components of functional fitness in younger old adults (aged 60-73 years) as well as older old adults (aged 74-86 years). In our previous studies, we conducted a WREP which included aerobic, resistance and flexibility exercises performed in a laboratory setting with three supervised sessions per week for 12 weeks in healthy older adults (Takeshima et al., 1999) and older outpatients (Yamauchi et al., 2003). The 12-wk supervised training program resulted in significant improvements in endurance, functional strength, flexibility, agility, serum lipids and blood pressure.

Unfortunately, in many cases, the benefits of exercise disappear after cessation of supervised training. Our follow-up survey nine months after completion of the supervised WREP in healthy older adults clearly demonstrated that the improvements in many physical indicators had notably deteriorated (Takeshima, 2002). In the follow-up study, we inquired about the participants' current exercise habits after completion of the supervised WREP, focusing on the type of exercises that they continued to perform. It was noted that walking was their main mode of exercise during the follow-up period and they did not perform resistance training. This was principally attributed to the fact that the training machines used for resistance exercise in the program were not available at home.

Recently, elastic band-based resistance exercises have become increasingly popular as an alternative to machine-based resistance exercises. Reports are available to establish the efficacy of elastic resistance bands which can be utilized by older adults of various fitness levels ranging from independently-living older adults (Rogers et al., 2002) to physically frail community-dwelling older persons (Gill et al., 2004).

In the late 1980s and early 1990s, home-based exercises (Atienza, 2001; Brubaker et al., 2000; Juneau et al., 1987; King et al., 1991) and community-based exercises (Hands et al., 1987; King et al., 1991; Miller et al., 1984) were prescribed for middle-aged and healthy older people or patients. Primarily, aerobic exercises were being prescribed at this point. Beginning in the mid-1990s, resistance exercises have also been included (Fatouros et al., 2002; Gill et al., 2004; Jette et al., 1996; King et al., 2000; Rogers et al., 2002; Skelton et al., 1995; Wood et al., 2001). These conventional studies determined the efficacy of either aerobic, resistance or flexibility exercise. However, little is known about the efficacy of a WREP performed in home-based settings. Based on these concepts and available data, we hypothesized that a home-based WREP would improve overall functional fitness of community-dwelling older adults. Thus, the purpose of our study was to evaluate the efficacy of a 12-week home-based WREP combined with community-based classes in a group of community-dwelling older adults.

METHODS

Participants

Community-dwelling persons residing in H., Nagoya were recruited through local Senior Societies and Residents' Associations. Participants in the study were: (1) sedentary individuals for whom exercise was not contraindicated for any health reason; and (2) aged 60 and older. The participants were randomly assigned to one of two groups: the exercise group or the control group. The exercise group consisted of 23 participants (aged 62-80 yr, average: 69.2 ± 5.2; 12 men and 11 women). Seven (3 men, 4 women) were taking medication for hypertension, one woman for diabetes, and two women for osteoporosis. The control group consisted of 17 participants (aged 63-85 yr, average: 70.1 ± 6.6; 5 men and 12 women). The control group originally included nine men. However, two of these men did not attend the post-assessments, and two others joined an exercise program, changing their exercise habits and consequently becoming ineligible for the study. Therefore, these four men were excluded, resulting in more women than men in the control group. Seven (4 men, 3 women) were taking medication for hypertension, and two (1 men, 1 women) for high cholesterol. General characteristics of the participants are described in Table 1.

Measurement of general characteristics

After lying supine for five minutes, resting systolic blood pressure (SBPrest), resting diastolic blood pressure (DBPrest), and resting heart rate (HRrest) were measured (Table 1) using an automated machine (Colin Stress BP monitor, STBP-680, Komaki, Japan). Body height and weight were measured using a TANITA body fat analyzer TBF-202 (Tanita Co., Tokyo, Japan). Body mass index (BMI) was computed as body weight (kg) divided by the square of height (m). The participants were asked to assess their health as good, average or poor.

Measurement of functional fitness

Upper body functional strength was assessed using the 30-second Arm Curl Test [AC] (Rikli and Jones,

Table 1. General characteristics of participants at baseline. Data are means (±SD).

	Exercise Group (EX) n = 23	Control (C) n = 17
Age (yr)	69.2 (5.2)	70.1 (6.6)
Weight (kg)	54.7 (9.6)	53.6 (7.9)
Height (m)	1.58 (.08)	1.55 (.05)
Body mass index (kg/m^2)	21.7 (.5)	22.7 (3.4)
SBPrest (mmHg)	131 (18)	139 (15)
DBPrest (mmHg)	78 (9)	84 (9)
HRrest (bpm)	77 (10)	82 (12)
Self assessed health condition (%)		
Good	61	59
Average	35	35
Poor	4	6
Take medications (%)	44	53
Education* (%)		
Completed secondary education	91	82
Completed higher education	9	18

*Secondary education includes junior high school education which is generally completed at the age of 15, and/or high school education which is generally completed at the age of 18. Higher education includes college or university level education of at least four years after secondary education.

1999a). On a signal, participants were instructed to flex and extend the elbow of the dominant hand, lifting a weight (men: 8-pound dumbbell, women: 5-pound dumbbell) through the complete range of motion, as many times as possible in 30 seconds. After a demonstration by the tester, a practice trial of one or two repetitions was given, followed by one 30-s test trial. The score was the number of repetitions completed within 30 seconds.

Lower body functional strength was assessed using the 30-second Chair Stand Test [CS] (Rikli and Jones, 1999a). On a signal, participants rose to 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. After a demonstration by the tester, a practice trial of one to three repetitions was given, followed by one 30-s test trial. The score was the total number of stands executed correctly within 30 seconds.

Dynamic balance and Agility was assessed using the 8-foot Up and Go Test [UG] (Rikli and Jones, 1999a). Participants fully seated in a chair, hands on thighs and feet flat on the floor. On a signal, participants stood from the chair, walked as quickly as possible around a cone which was placed 8 feet (2.44 m) ahead of the chair, and returned to a fully seated position on the chair. Participants were told that this is a timed test and that the object was to walk as quickly as possible (without running) around the cone and back to the chair. After a demonstration by the tester, participants were given one practice trial and two test trials. The best performance time of the test trials was recorded in units of 0.1 second.

Upper body flexibility was assessed using the Back Scratch Test [BS] (Rikli and Jones, 1999a). Participants placed the preferred hand behind the same side shoulder with the forearm pronated and fingers extended. They placed the other hand behind the back, forearm supinated, reaching up in an attempt to touch or overlap the extended middle fingers of both hands. After a demonstration by the tester, participants were asked to determine the preferred hand, and were given two practice trials, followed by two test trials. The score was the number of centimeters the middle fingers were short of touching (minus score) or overlapped each other (plus score). The best score of test trials was used to evaluate performance.

Lower body flexibility was assessed using the Chair Sit and Reach Test [SR] (Rikli and Jones, 1999a). Participants sat on the edge of a chair with one leg bent and the other leg extended straight in front with the heel on the floor. Without bending the knee, participants slowly reached forward, sliding the hands down the extended leg in an attempt to touch the toes. After a demonstration by the tester, participants were asked to determine the preferred leg and were given two practice trials on that leg, followed by two test trials. The score was the number of centimeters short of reaching the toes (minus score) or reached beyond the toes (plus score). The best score of two test trials was used to evaluate performance.

Endurance was assessed by performing the 12-minute Walk Test [12-MW] (Takeshima et al., 1992). The 12-minute Walk Test involved assessing

the maximum distance walked in 12 minutes around a 60-meter rectangular course marked into 5-meter segments. The score was the total number of meters walked in 12 minutes.

Exercise program

The home-based exercise program consisted of flexibility, resistance and aerobic exercises. Participants were instructed to perform exercises at least three times a week in addition to the weekly supervised exercise class. They were advised to choose the mode of exercise for each home-based session based on the weekly supervised exercise class. A pictorial guidebook and a videotape were provided to each participant to assist them in correct exercise performance. The pictorial guidebook and the videotape were developed by the researchers using trained fitness instructors and older adults as models.

Flexibility exercise (stretching)

Participants were asked to perform several types of stretching each time from eight types of upper body exercises and seven types of lower body exercises described in the guidebook. These exercises were performed as warm up and cool down activities before and after performing aerobic or resistance exercises. Exercises were performed slowly, holding each position for approximately 10 to 12 seconds. Participants were instructed to stretch to a point of moderate tension without pain in the joints or muscles, gradually increasing the range of motion.

Elastic band-based resistance exercise

In order to train all major muscle groups, resistance exercises were prescribed as a combination of eight upper body exercises and nine lower body exercises performed in the seated position using an elastic resistance band (Thera-Band®, Hygenic, USA). Participants were instructed to progressively increase resistance every two to four weeks by advancing to the next color of elastic band (lower to higher resistance of bands in order: tan, yellow, red, green, blue, black, silver and gold). Specifically, participants were instructed to change bands when they were able to perform 20 repetitions of a given motion with little exertion. Exertion was rated using Borg's Rate of Perceived Exertion (RPE) scale (Borg, 1982). Participants were instructed to start resistance exercises at an intensity level of 11 to 13 of Borg's RPE scale and then to progressively increase to a level of 15 to 17. However, actual setting of resistance was very subjective. Participants were instructed to not hold their breath during the exercises in order to prevent exercise-induced blood pressure elevations.

Aerobic exercise (walking)

Participants were instructed to walk regularly around their home and parks near the community center as much as possible. Participants were instructed to walk at an intensity corresponding to a heart rate of 100-120 bpm. Maximal heart rate (HRmax) was not measured directly, however, in a previous study we found that a HR of 100-120 bpm represented an intensity of 70% to 80% of HRmax for people aged approximately 70 years (Takeshima et al., 1993). In the community-based maintenance exercise class, each participant wore a heart rate monitoring device (Accurex Plus, Polar Electro, Kempele, Finland) that

Table 2. Effects of home-based well-rounded exercise on functional fitness. Data are means (±SD).

	Baseline	Post	Absolute Change	ANOVA (Group × Time)
Arm Curl (AC, times/30sec)				
EX group	18.8 (3.4)	22.2 (3.9)	3.4	F (1, 38) = 16.08
C group	21.8 (4.1)	21.9 (4.3)	.1	p < .05
Chair Stand (CS, times/30sec)				
EX	20.0 (4.6)	21.2 (3.8)	1.2	F (1, 38) = 4.33
C	22.2 (3.8)	21.1 (4.1)	-1.1	p < .05
Up & Go (UG, sec)				
EX	4.8 (.5)	4.2 (.4)	-.6	F (1, 38) = 17.00
C	4.5 (.5)	4.3 (.6)	-.2	p < .05
Back Scratch (BS, cm)				
EX	-4.5 (12.3)	-4.3 (12.8)	.2	F (1, 38) = 6.05
C	-2.7 (9.0)	-4.9 (9.6)	-2.2	p < .05
Sit & Reach (SR, cm)				
EX	2.1 (9.6)	9.5 (11.6)	7.4	F (1, 38) = 12.25
C	2.6 (15.8)	2.9 (15.8)	.3	p < .05
12-min Walk (12-MW, m)				
EX	1136 (255)	1223 (254)	87	F (1, 38) = 12.25
C	1125 (94)	1146 (160)	21	p < .05

Table 3. Time spent in exercises and perceived exertion in home-based exercise. Data are means (±SD).

Exercise Mode	Frequency (days·wk^{-1})	Duration (min·day^{-1})	RPE(range)
Flexibility	3.9 (1.7)	19 (4)	NA
Resistance	3.0 (1.5)	26 (7)	12.7 (.8)
Aerobic	2.5 (1.4)	37 (21)	12.3 (.8)

each participant wore a heart rate monitoring device (Accurex Plus, Polar Electro, Kempele, Finland) that continuously monitored his or her HR during the class. Participants were asked to walk at speeds that represented their regular walking exercise speeds, and were informed of their recorded heart rate. Advice was given to those needing to increase or decrease exercise intensity to maintain the prescribed intensity.

Exercise classes at a community center

Maintenance exercise classes were held once a week at a local community center to provide participants with instruction regarding correct exercise techniques. These sessions were conducted by trained exercise instructors and supervised by the researchers. Each maintenance class consisted of general warm-up exercises (10min), elastic band-based resistance exercise (40 min) or walking-based aerobic exercise (40 min), and cool-down/relaxation exercises (10 min). Adherence rate was calculated as the number of maintenance classes attended divided by the number of total maintenance classes.

To determine actual implementation of home-based exercise, participants were asked to submit a diary every week when attending the exercise classes. Participants were asked to record exercises performed with regard to body part exercised as well as the type, frequency, duration and intensity of exercise.

Data processing

The data are expressed as mean ± standard deviation. The effect of the intervention was determined using a 2-way ANOVA with repeated measures. Between group mean baseline comparisons were performed using a two-tailed, independent t-test. To determine relationships between variables, Pearson product-moment correlation analyses were calculated. A P value, set a priori, of less than 0.05 was considered statistically significant.

RESULTS

No differences were found between the exercise group and the control group before the intervention in terms of age, weight, height, BMI, SBPrest, DBPrest, and HRrest (Table 1). As for the participants' self-assessed health condition, 14 participants (61%) in the exercise group and 9 participants (59%) in the control group reported that they were in good condition (Table 1). Ten participants (44%) in the exercise group and 9 participants (53%) in the control group were taking medication. Approximately 85% of the participants had completed secondary education. No differences were observed between the two groups in terms of self-assessed health condition or educational background (Table 1). Before the intervention, there were no significant differences between the groups for AC, CS, UG, BS, SR or 12-MW, however, after the 12-wk intervention significant group interactions as well as time effects were observed for all functional fitness scores (Table 2).

Frequency and duration of exercise

The exercise group performed home-based exercises (in addition to the maintenance classes) on 4.3 ± 1.3 days·week^{-1}. Average total exercise duration was 248 ± 107 min·week^{-1}. Flexibility exercise was performed on 3.9 ± 1.7 days·week^{-1} with an average exercise duration of 19 ± 4 min/day. Resistance exercise was performed on 3.0 ± 1.5 days·week^{-1} with an average exercise duration of 26 ± 7 min·day^{-1} and an average RPE of 12.7 ± 0.8. With respect to beginning levels of elastic band resistance (band resistance - lower to higher: tan, yellow, red, green, blue, black, silver and gold), 6 of 11 women (55%) chose yellow and 5 women (46%) chose red. Among 12 men, 7 men (58%) chose red, 3 men (25%) chose green, and 2 men (17%) chose blue. At the end of the intervention, 1 woman (9%) used yellow, 9 women (82%) used red, 1 woman (9%) used green; 4 men (33%) used red, 5 men (42%) used green, and 3 men (25%) used blue. These observations indicate that the participants progressively increased the level of resistance, and therefore exercise intensity, during the intervention. Aerobic exercise was performed on 2.5 ± 1.4 days·week^{-1}, with an average exercise duration of 37 ± 21 min and an average RPE of 12.3 ± 0.8 (Table 3).

Adherence and exercise duration

The average adherence rate in the exercise class at the community center was 83 ± 11%. Significant correlations were observed between adherence rate and total time spent engaging in the home-based exercise program (average = 248 ± 107 min·week^{-1}, $r = 0.73$, $p < 0.05$). There were no accidents or

injuries during the exercise classes at the community center or at home. All participants in the exercise group completed the entire 12-week home-based exercise program.

DISCUSSION

A well-rounded exercise program (WREP) is considered to be an effective exercise program for attenuating deterioration in functional fitness associated with aging and a sedentary lifestyle. Wood et al. (2001) conducted programs for older adults which included cardiovascular training (CVT), resistance training (RT) or both CVT and RT. They concluded that the program incorporating both CVT and RT is more effective in improving functional fitness than the programs involving only one component. Barnett et al. (2003) recruited elderly subjects who were at risk of falling. They prescribed a program including aerobic, flexibility and resistance exercises, and found improvements in balance and a decrease in the prevalence of falls. Rogers et al. (2002) provided African-American elderly women with community-based exercise classes using elastic resistance bands and observed improvements in upper and lower body strength. Aniansson et al. (1984) studied elderly women and prescribed resistance exercise sessions using elastic bands and found increases in muscle strength. Jette and colleagues (1996; 1998; 1999) examined resistance training with elastic bands in several studies and concluded that balance and functional fitness as well as muscle strength improved. The present study examined a home-based WREP in Japanese older adults. We found the program to be effective for improving endurance, functional strength, agility and flexibility. However, additional research is needed to determine the specific types and amount of exercise that should be performed to provide optimal fitness benefits.

In this study, elastic bands were used for resistance training because they are simple, portable and inexpensive tools. They do not require large storage space or special facilities, and can be easily used for both community- and home-based exercises (Gill et al., 2004). Eight to ten types of exercises were introduced for the upper and lower body, and each motion was to be repeated 10-12 times (Feigenbaum and Pollock, 1997). As a result, we observed improvement in the AC and CS. Furthermore, the UG also improved in the exercise group. Other studies support the effectiveness of elastic bands as resistance exercise (Barnett et al., 2003; King et al., 2000; Rogers et al., 2002).

In the current study, participants were encouraged to walk for aerobic exercise. Participants were instructed to maintain prescribed exercise intensity by monitoring their pulse. They walked an average of 2.5 days·week^{-1} for 37 min·day^{-1}. As a result, endurance of the exercise group as measured by the 12-MW improved significantly. However, some challenges still remain for prescribing home-based aerobic exercises. Outdoor exercises can be interrupted by inclement weather, while the housing situation often does not allow enough space for placing a treadmill or a stationary bike in the homes of older adults.

Joint range-of-motion deteriorates in accordance with age, especially in sedentary older adults. This can lead to difficulty in performing daily living activities such as bathing and dressing, and can contribute to falls that cause injuries (Barnett et al., 2003). Furthermore, the decline in lower body flexibility can negatively affect walking speed. Campanelli (1996) reported that the age-related changes in flexibility are largely related to declines in physical activity, though the degree of deterioration differs among individuals. Fatouros et al. (2002) examined inactive older adults, performing 16 weeks of aerobic and resistance exercise, and observed remarkable improvement in joint range of motion. We measured flexibility of upper and lower body using Back Scratch and Sit & Reach tests which have been validated by Rikili and Jones (1999a) and adopted in other studies (Marzilli et al., 2004; Toraman and Sahin, 2004). Our study observed significant increases in flexibility in BS and SR in exercise group. Although BS scores of the control group showed decrease by 2.2cm, it should be noted that the scores of three control participants were deemed outliers due to an extremely large decrease in post-intervention BS scores showing mean change of -9.8 cm within these three people. Mean change excluding these three people was -0.6 cm. These three participants experienced a shoulder joint injury resulting in poor post-intervention performance. Their injuries were not related to the exercise program itself. A small stimulus such as carrying groceries or carrying a shoulder bag could have caused upper body muscle pain or shoulder joint pain in these people, and it may have affected their BS performance. Unfortunately, no effort was made to study specific shoulder joint pain during pre and post tests in this study. However, the noted improvements in the exercise group may help these individuals to live independently for longer periods of time and to continue to perform activities such as combing hair, dressing and undressing.

Motivating older adults to perform exercises on a regular basis is an important factor in achieving high adherence rates and maintaining the effects of exercise. Data from Martin and Sinden (2001) suggest that occasional direct contact with the participants via telephone, internet or personal visit

increases adherence to home exercise programs among older adults. In our previous study, we provided supervised exercise classes three days a week for 12 weeks for older adults (Yamauchi et al., 2003). The adherence rate was 94% and most participants mentioned that they were glad to make new friends and enjoyed exercising as a group. This suggests that community-based exercise classes in a group setting have positive psychological effects as well as physical effects. In the current study, we held community-based exercise classes once a week in addition to the home-based exercise program. The adherence rate to the community-based classes was 83%, and a positive correlation was observed between the adherence rate and the performance of home-based exercise. These facts suggest that the community-based exercise classes promoted exchanges among the participants, and successfully developed incentives for exercise participation. After completion of this 12-week program, participants continued to exercise and currently attend exercise classes twice a month with the aim of observing fitness changes that may occur over an extended period of time.

To evaluate exercise effects, we used a functional fitness test battery that was originally developed and validated by Rikli and Jones (1999a) of the United States. This battery can be easily performed by older adults and normative scores for the tests are available (Rikli and Jones, 1999b). The participants in the present study showed better test scores in almost all the variables compared to their age-matched normative scores. This may suggest that Japanese people demonstrate greater functional fitness than age-matched American people. Two previous studies have yielded similar findings. Both Davis et al. (1999) and Loy et al. (2001) report better functional fitness scores in older Japanese persons compared to Caucasian subjects. Rationale to explain the higher functional fitness levels of Japanese subjects has yet to be determined, however, it is possibly related to genetic and cultural factors. For example, squatting to toilet or getting up from the floor, which are commonly performed in Japanese daily life, may help maintain lower body functional strength, while going shopping on foot and carrying groceries by hand may also be helpful in maintaining muscular strength. However, little information is provided regarding Asian racial groups in the literature (Atienza, 2001) posing a need for future research.

CONCLUSIONS

A WREP has been shown to improve overall fitness in older adults. By combining aerobic, resistance and flexibility exercises, a WREP was effective for improving endurance, functional strength, dynamic balance and agility, and flexibility. Furthermore, a high correlation was observed between adherence rate of community-based exercise classes and performance of home-based exercise, indicating that community-based exercise promotes participation in home-based exercise.

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KEY POINTS

- Walking, elastic band exercise and stretching were prescribed as a Well-Rounded Exercise Program for older adults.
- By combining aerobic, resistance and flexibility exercises, a Well-Rounded Exercise Program was effective for improving endurance, functional strength, dynamic balance and agility, and flexibility.
- Community-based exercise classes motivated older adults to perform home-based exercises.

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