Decline in Age-associated Functional Fitness after a 10 year Peer-instructed Community-based Exercise Program

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Objective: To determine changes in functional fitness of older adults following 10 years of peer-instructed community-based exercise program participation. Subjects: Eighteen participants (65.6 ± 8.3 yr) were assessed at pre-intervention (T1), post-12 weeks (T2), and post-10 years (T3). Method: General physical parameters, functional strength (Arm Curl [AC], Chair Stand [CS]), flexibility (Back Scratch [BS], Sit & Reach [SR]), balance (functional reach [FR]), agility (Up & Go [UG]), and endurance (12-min walk [12-MW]) were measured. After completion of an initial 12-wk of professionally-supervised community-based exercises (aerobic, resistance, flexibility and balance), the participants continued the exercises under the guidance of similarly-aged peer-instructors for the next 10 years which consisted of 10 min of warm-up, 30 min of elastic band-based resistance exercise, 10 min of balance exercise and 10 min of cool-down exercises (excluding any formal aerobic exercises), twice a week at a local community center. Results: Changes in AC (−3.0%), CS (−5.8%), SR (+7.1%), BS (−49.3%) and UG (−36.2%) over 10 years were not significant (P > 0.05). However, a significant (P < 0.05) decline was noted in 12-MW (−18.8%) and FR (−22.7%) over 10 years. Conclusion: Peer-instructed community-based exercises are useful in attenuating the age-associated decline in muscular strength, flexibility, and agility over an extended period of time.

Keywords: functional fitness decline rate, longitudinal study, community leader guided exercises, old age

1. Introduction

It is well known that functional fitness declines are associated with advancing age (Forrest et al., 2006) which may eventually compromise the ability to perform activities of daily living (ADL) (Freedman et al., 2002; Lindle et al., 1997; Rantanen et al., 2002). The rapidly growing older adult population in Japan is also associated with an increase of frail elderly. Moreover, young adults are tending to move from rural areas of Japan to urban areas. Therefore, older adults in rural areas have an increased dependence on one-another in their everyday life. Functional fitness then becomes essential for an older adult to perform their own ADL as well as to assist other older adults in performing ADL.

Research over the past two decades clearly shows that regular physical exercise is effective for maintaining and promoting functional independence in older adults (Nelson et al., 2007). Recently, community and home-based exercises are becoming increasingly popular among older adults (Yamauchi et al., 2005). Professional exercise instructors under the supervision of exercise researchers can conduct such exercises efficiently for older adults. Unfortunately, professional exercise instructors are not commonly available in rural areas and it is very difficult for older adults in rural Japan to continue these exercises by themselves. However, older adults from within the same community who earlier par-
participated in a supervised short-term exercise program may be able to take leadership roles and serve as peer-exercise-instructors. These peer-instructors can conduct the same exercises regularly on a long-term basis and provide fellow older adults with the opportunity to continue their exercise program. Based on this concept, the aim of this study was to assess functional fitness changes in a group of older adults from a community in rural Japan who continued a community-based exercise program for ten years under the guidance of peer-exercise-instructors.

2. Method

2.1. Subjects

Community-dwelling middle-aged and older adults residing in Fube Village of Yasugi city of Shimane Prefecture in Japan were recruited through a Local Residents Association and through the respective City Corporation. 32 community-dwelling older adults successfully completed an initial 12-week supervised exercise program in 2003. Twenty (62.5% of initial participants) of them decided to continue exercises by themselves for a longer period of time. However, two participants who continued exercises for 10 years did not participate in the testing at post-10 years level. One of these two participants started a new job and failed to attend this testing, the other one failed to attend testing due to personal reasons. Thus, the data of 18 participants (56.2% of initial participants) were used for analysis, of them 17 participants were female and one was male (initial age 65.6 ± 8.3 yrs). These 18 participants were relatively young and fortunately, they suffered no major life events that could force them to be absent from exercise classes for more than four consecutive weeks during the 10-year period.

The organizers of the 2003 supervised exercise program (i.e., the current research team) promised to assist them by providing necessary materials such as exercise manuals, exercise tools, etc. The participants selected peer-exercise-instructors from among themselves who took turns to conduct exercise sessions during the following 10 years. The ethical committee of the National Institute of Fitness and Sports in Kanoya approved the study. All participants received written and oral instructions for the study and each gave their written informed consent before participation.

2.2. Professionally supervised exercise class at the community center

The 12-week supervised exercises in 2003 consisted of warm-up (10 min), combined elastic band-based resistance exercise and floor-based aerobic exercises in a circuit fashion (30 min), balance exercises (10 min) and cool-down exercises (10 min) on two days a week. The exercise program was conducted by an expert exercise instructor and supervised by exercise scientists from a university.

2.3. Peer-exercise-instructors guided exercise class at the community center

Each of the peer-instructor exercise classes consisted of 10 min of warm-up, 30 min of elastic band-based resistance exercise, 10 min of balance exercise and 10 min of cool-down exercises. The peer-exercise-instructors mastered the correct methodology of performing these exercises from the 12-wk supervised exercise program in 2003 where each of them participated actively (Figure 1 and Figure 2). Moreover, a pictorial guidebook was provided to all participants by the research team to serve as a resource for correct exercise performance. Peer-instructors would review the guidebook prior to each session in order to familiarize themselves with the correct methodology before instructing a class.

All participants took turn to conduct exercise classes. Better performing peer-instructors conducted more sessions compared to those who were identified as lower-quality peer-instructors. Two of the better instructors also began leading exercise classes for other communities. They were absent from the peer-instructed exercise classes when they went outside the community to instruct other exercise classes.

In order to train all major muscle groups, resistance exercises were prescribed by using elastic resistance bands (Thera-Band®, Hygenic, USA) which was performed for 1 set of 12 repetitions per session (Feigenbaum and Pollock, 1997).

Stretching exercises were performed slowly and the participants were asked to stretch to the point where they felt moderate tension without feeling pain in joints or muscles. The balance exercises (Figure 2) included placing the feet in various positions (e.g., feet together, tandem positions, and
Figure 1. Elastic band-based supervised resistance exercises at the community center.

Figure 2. Supervised balance exercises at the community center.

standing on one leg) while performing various movements that challenged their balance ability (Islam et al., 2004).

2.4. Measurements

Body height, mass, BMI, and functional fitness were measured before (T1) and after (T2) the 12-wk exercise intervention, and then after 10 years (T3) of peer-instruction. All measurements were completed within one week before and after the interventions. A battery of field tests was used to assess the components of functional fitness having good test-retest reliability and validity (Duncan et al., 1990; Rikli and Jones, 1999; Miotto et al., 1999; Rogers, 2003).

Upper-body strength was assessed using the 30-s Arm Curl Test [AC] (Rikli and Jones, 1999) where 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-second Chair Stand Test [CS] (Rikli and Jones, 1999) where 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 (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] (Rikli and Jones, 1999) and Functional Reach Test [FR] (Duncan et al., 1990). To perform UG, 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 of the test trials was recorded in units of 0.1 second. Participants walked through the test one time as a practice and then were given two test trials with the best performance time used for analysis. To perform the functional reach, the participant stood with feet together and both arms raised in front horizontally and held at the 0 centimeter level of the functional reach scale and then leaned forward, moving the hands forward along the scale as far possible without losing 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.

Shoulder joint flexibility was assessed using the Back Scratch Test [BS] (Rikli and Jones, 1999) where participants placed the preferred hand behind the same side shoulder 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 (minus score) or overlapped each other (plus 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] (Rikli and Jones, 1999) where participants sat on a chair and then slowly reached forward, sliding the hands down an extended leg in an attempt to touch the toes (without bending the extended knee). The score was the number of centimeters short of reaching the toes (minus score) or reached beyond the toes (plus score). A practice trial of one or two times was given, followed by two test trials with the best performance used for analysis.

Cardio-respiratory 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 (Takeshima et al., 1992; Yamauchi et al., 2005). The score was the total number of meters walked in 12 minutes.

### 2.5. Data analysis

Changes in measured variables over time (for age) were evaluated using the analysis of variance (ANOVA) followed by post hoc testing (Bonferroni). Percent changes were calculated from the differences in scores. A probability value of less than 0.05 was considered statistically significant.

### 3. Results

ANOVA revealed that change in body mass (T1: 53.1 ± 7.3; T2: 53.2 ± 7.8; T3: 51.4 ± 7.4; kg) and BMI (T1: 23.7 ± 2.6; T2: 23.7 ± 2.8; T3: 23.5 ± 3.1) with age were minimal (Table 1). However, body height (T1: 149.7 ± 6.0; T2: 149.6 ± 5.7; T3: 147.8 ± 6.0; cm) decreased significantly with age by 2 cm during the 10 years of study period (Table 1).

AC (T1: 27.8 ± 6.1; T2: 27.5 ± 5.3; T3: 26.7 ± 8.5; times/30sec), CS (T1: 27.9 ± 8.1; T2: 27.3 ± 6.4; T3: 25.8 ± 8.0; times/30 sec), SR (T1: 19.8 ± 9.9; T2: 18.4 ± 8.1; T3: 19.7 ± 10.3; cm), BS (T1: −4.6 ± 11.7; T2: −7.3 ± 12.9; T3: −10.9 ± 17.2; cm), and UG (T1: 5.0 ± 2.1; T2: 4.7 ± 1.9; T3: 6.4 ± 4.6; sec) showed no significant change with age during the 10 years of study period between T2 and T3 (Table 2).

Adherence rate to the peer-exercise-instructors guided exercise classes at the community center during the 10-year exercise program ranged from 34% to 100% for different participants.

### 4. Discussion

Aging is associated with a gradual decrease in the components of functional fitness. It was reported in a review study that the average rates of muscular strength loss in older people are 2-4% per year (Mitchell et al., 2012). In the current study (Table 2), the decline in AC was 0.3% per year (3.0% over 10 years) and in CS was 0.6% per year (5.8% over 10 years) which is much lower than average declines in strength. Although strength was not entirely maintained, attenuation of the expected loss is likely due to the community-based exercises they performed as it has been reported that strength training can result in improvements in muscle size and strength in older men and women (Rogers and Evans, 1993).

The change in SR (P = 1.000) and BS (P = 0.074) was not significant (Table 2) indicating that decline in lower body flexibility and shoulder joint flexibility was probably maintained by virtue of the community-based exercises they performed. Of course, the

### Table 1. General characteristics of participants.

|                | T1          | T2          | T3          | % change between T2 and T3 | F Statistic |
|----------------|-------------|-------------|-------------|----------------------------|-------------|
| Age (yrs)      | 65.6 ± 8.3  | 65.9 ± 8.3  | 75.5 ± 8.3  | −1.2                       | F(2, 16) = 38.53 |
|                |             |             |             |                            | P = 0.001   |
| Height (cm)    | 149.7 ± 6.0 | 149.6 ± 5.7 | 147.8 ± 6.0 | −3.5                       | F(2, 16) = 4.01 |
|                |             |             |             |                            | P = 0.151   |
| Body mass (kg) | 53.1 ± 7.3  | 53.2 ± 7.8  | 51.4 ± 7.4  | −0.8                       | F(2, 16) = 0.13 |
|                |             |             |             |                            | P = 1.000   |
| BMI            | 23.7 ± 2.6  | 23.7 ± 2.8  | 23.5 ± 3.1  | −0.8                       |             |
|                |             |             |             |                            |             |
Changes in functional fitness performance over 10 year period. Decline over 10 per decade change between T1 and T2 (post hoc)

| FF Parameters | T1          | T2          | % change between T1 and T2 (post hoc) | T3          | % change between T2 and T3 (post hoc) | F Statistic (ANOVA) |
|---------------|-------------|-------------|---------------------------------------|-------------|---------------------------------------|---------------------|
| AC (times/30 sec) | 27.8 ± 6.1  | 27.5 ± 5.3  | -1.1 (P = 1.00)                       | 26.7 ± 8.5  | -3.0 (P = 1.00)                       | F(2, 16) = 0.62     |
| CS (times/30 sec) | 27.9 ± 8.1  | 27.3 ± 6.4  | -2.2 (P = 1.00)                       | 25.8 ± 8.1  | -5.8 (P = 0.653)                      | F(2, 16) = 1.87     |
| SR (cm)      | 19.8 ± 9.9  | 18.4 ± 8.1  | -7.6 (P = 1.00)                       | 19.7 ± 10.3 | +7.1 (P = 1.000)                      | F(2, 16) = 0.47     |
| BS (cm)      | -4.6 ± 11.7 | -7.3 ± 12.9 | -58.7 (P = 0.026)                     | -10.9 ± 17.2| -49.3 (P = 0.074)                     | F(2, 16) = 10.79    |
| I2-MW (m)    | 1098.0 ± 116.3 | 1126.1 ± 142.3 | +2.5 (P = 0.509)                     | 947.6 ± 199.6 | -18.8 (P = 0.003)                    | F(2, 16) = 15.72    |
| UG (sec)     | 5.0 ± 2.1   | 4.7 ± 1.9   | +6.4 (P = 0.290)                      | 6.4 ± 4.6   | -36.2 (P = 0.082)                     | F(2, 16) = 4.95     |
| FR (cm)      | 31.8 ± 7.7  | 33.5 ± 7.0  | +5.3 (P = 0.855)                      | 27.3 ± 9.4  | -22.7 (P = 0.013)                     | F(2, 16) = 6.08     |

FF: functional fitness; T1: pre-intervention test values; T2: post-12 weeks (post professionally supervised exercise) test values; T3: post-10 years (post peer-instructed exercise) test values; AC: arm curl test; CS: chair stand test; SR: sit and reach test; BS: back scratch test; I2-MW: 12 minute walk distance test; UG: up and go test; FR: functional reach test

age-related changes in flexibility have large individual variation (Campanelli, 1996).

In our study, the decline in aerobic capacity (12-MW) was 18.8% over 10 years (Table 2). A previous report found a decline of 9.1% per decade in aerobic capacity (VO₂max) in sedentary healthy women (Tanaka et al., 1997). During the initial 12-wk of supervised community-based exercises in the current study, participants performed aerobic exercises combined with elastic band-based resistance exercise in a circuit fashion. These aerobic exercises were mostly dance-like movements performed while following the guidance of professional exercise instructors (Figure 1). However, during the following 10 years of peer-exercise-instructor guided exercises, the participants excluded this aerobic training from the program because they were not confident they could perform them correctly without the guidance of a professional exercise instructor. An improvement in their aerobic performance was noted during the initial 12 weeks of professional-instructor guided training followed by a significant decline during the next 10 years of peer-instructor guided exercises (Table 2). In one of our previous studies, we found that improvement in cardiorespiratory fitness must include aerobic training, so improve cardiorespiratory fitness, older adults need to perform some type of aerobic-specific activity (Takeshima et al., 2007). The 18.8% decline over 10 years in the current study may thus represent the natural course of age-associated decline in aerobic capacity as the participants did not perform any formal aerobic exercises during the 10 years of peer-exercise-instructor guided exercises.

Balance performance (UG and FR) did not change significantly during the initial 12 weeks of professional-instructor guided training followed by a significant decline in FR during the next 10 years of peer-instructor guided training (Table 2). This was probably because they performed only 10 minutes of balance exercises per session in the current study which may not be enough to provide adequate stimulus to improve FR or at least to maintain FR performance with age that is the ability to move the center of gravity in the forward direction. It was reported in a previous study that older adults gained significant improvement in moving their center of gravity in the backward, right and left directions but no significant improvement was found in moving their center of gravity in the forward direction even after performing 40 minutes of customized balance exercises per day (Islam et al., 2004). Decline in UG (P = 0.082) was not significant indicating that agility-associated balance was somehow maintained by virtue of the community-based exercises they performed.

Decline in body mass and BMI was minimum over 10 years (Table 1). However, body height decreased significantly by 2 cm over 10 years (Table 1) may be due to the effect of age-associated bone loss.
The initial 12-wks exercise program was designed and completely supervised by researchers from a university. As discontinuation of the program may deteriorate the gained benefits, participants became motivated to continue exercising by themselves even if a professional exercise instructor was not available to guide them. Researchers from the initial exercise program occasionally met them during this 10-year period which also motivated them to continue exercising by themselves. The 18 participants who completed the 10-year long exercise program initially were not very familiar with one-another although they lived in the same community. There were no special meeting facilities in this community where people could get together on a regular basis. During the initial 12-wk supervised exercise program they started to know one another intimately which continued during the 10-year exercise program. They became so familiar with each other that they shared information with one another about their life events (such as while suffering from a medical condition or when a relative passed away etc.) and tried to overcome the sorrows or pain they felt from these life events.

During this 10-year period, three participants got admitted to hospitals after suffering falls and/or bone fractures. However, they recovered from these medical conditions quickly, perhaps because of their maintained physical fitness. One of them surprised hospital staff members by teaching elastic band-based resistance exercises to some other in-patients during her hospital admission period. This probably happened because of her high motivation to exercise and the confidence gained from peer-instruction experience. None of the 18 participants needed care-insurance support during the 10 years of training. However, one of them recently started to receive care-insurance benefit when she reached 90 years of age. No major deterioration in cognition was reported in these 18 participants during the study period. Two of participants were single living and the rest of them enjoyed family life at least with their spouses. They enjoyed relatively independent ADL during this 10-year study which might have been influenced by the peer-instructed exercises. Future studies are needed to explore all factors including effects of regular exercises that may facilitate independent ADL until advanced life in this community.

The participants of the current study came from a rural village where the population aged 65 years or above was 41% of its total population in 2013 which was much higher than Japan’s national rate (25.9%) in 2013 (Shimane Prefecture, 2013). Community and home-based exercises are reported to be beneficial for older adults especially for those living in rural settings (Gillis et al., 2002). Obtained benefits of maintaining functional fitness or at least in attenuating the decline of functional fitness in participants of the current study demonstrates the usefulness of peer-exercise-instructors guided community-based training programs in rural settings. The peer-leaders likely played a vital role in sustainability of this exercise program for the long 10-year period. The content of the exercise program was designed in such a way so that older adults could exercise without many difficulties and also likely increased their motivation to continue the program for 10 years.

In general, effects of age, gender, and physical or mental conditions should be adjusted while analyzing the data of an intervention study. However, it is not easy to follow up the concerned life events in the aged people for such a long time. Although it was difficult to adjust these factors in the current study, however, the results of this decade long prospective study could be valuable for designing community-based exercise in older adults.

A limitation of this study is that data were not collected periodically during the 10-year study period. Annual or bi-annual data collection and data feedback to participants could magnify the outcome of this study and thus future study is needed to assess the efficacy of periodic test feedback during peer-exercise-instructor-guided exercises at community settings. Having researchers guide supervised exercise classes at least twice a year could help peer-instructors to conduct exercise classes more effectively. Future studies are needed to address this issue.

5. Conclusion

These results suggest that peer-exercise-instructor-guided community-based exercise programs are useful in controlling the age-associated decline of muscular strength, flexibility and agility for an extended period of time.
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