Journal of
PHYSIOLOGICAL
ANTHROPOLOGY

# The Long-term Effects of Progressive Resistance Training on Health-related Quality in Older Adults

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**Abstract** This study examined the persistence rate of resistance training after intervention with progressive resistance training and the long-term changes in self-perceived function as Heath-related quality of life (HRQOL) between a maintaining group (TR) and a detraining group (DT) after the intervention.

One hundred sixty-seven persons aged 65 and older participated in this study. We measured SF-36 as indices of HRQOL before intervention (T1), after intervention (T2), and 1 year later (T3).

We assessed 135 participants at T3, and, of these, 58 were in TR and 77 were in DT. In TR, T2 scores significantly improved over T1 scores for Physical Functioning, Role Physical, and Mental Health ($p<.05$–$.01$). Moreover, in T3 scores, Physical Functioning ($p<.01$) and Role Physical ($p<.05$) significantly improved over T1 scores. In DT, T2 scores were significantly higher than T1 scores for Vitality and Mental Health (both $p<.01$), while T3 scores significantly decreased from T2 scores for Physical Functioning, General Health, Vitality, and Mental Health ($p<.05$–$p<.01$). Only Physical Functioning of TR was significantly higher than that of DT in T2. However, Physical Functioning, Role Physical, General Health, Vitality, and Mental Health of TR were significantly higher than that of DT in T3 ($p<.05$–$.01$). No subscale scores at T3 were significantly lower than at T1.

Our findings suggest that for the elderly, voluntarily continuing training after the structured program has beneficial effects for HRQOL, and the differences in HRQOL with regard to how to spend time after the intervention over the long term. However, it was possible for the HRQOL of the participants to deteriorate, though not significantly, at 1 year after the intervention in comparison to the baseline. This result suggests that the significant HRQOL gains of the DT group for the intervention period are very important. *J Physiol Anthropol 27(2): 57–61, 2008* http://www.jstage.jst.go.jp/browse/jpa2
[DOI: 10.2214/jpa2.27.57]

**Keywords:** HRQOL, longitudinal study, community-dwelling elderly persons

## Introduction

Maintaining the good health of the elderly population is a major issue in public health. Several previous studies have examined the improvement of fitness and physical function of older adults. In recent years, there have been clinical statements in geriatrics (Bortz, 1980, 1989; Buchner, 1997) and increasing research evidence (Rejeski et al., 1996; Stewart et al., 1997) that physical activity is a viable strategy for improving the health-related quality of life (HRQOL) of older adults (Rejeski and Mihalko, 2001). Furthermore, recent studies have examined the effects of resistance training (Singh et al., 1997) on HRQOL among older adults.

However, most of these studies were entirely focused on the changes in HRQOL between the periods before and after the intervention. These results may not be adequate due to the lack of retention of the effects of the intervention, namely either increasing, maintaining, or decreasing HRQOL in older adults. In addition, the effects of progressive resistance training (PRT) on more substantive outcomes such as measure of disability or HRQOL remain unclear (Latham et al., 2003). It is necessary to examine whether or not participants continue to exercise following the intervention and to investigate the changes in physical functions and HRQOL. We found PRT and balance training to have important effects on physical functions that are still present after 1 year in community-dwelling older adults (Inaba et al., 2006). Not only physical functions, but clarifying the retention effect on the HRQOL of participants after the PRT and balance training may also help to elucidate the environmental adaptability and physiological polymorphisms of the older adults. We hypothesized therefore that HRQOL gains achieved during the 12-week exercise program would be

maintained if subjects are engaged in resistance training 1 or more days per week, and that HRQOL would be reduced when the subjects returned to their normal free-living lifestyles.

The purposes of this study were: 1) to research the persistence rate of voluntary resistance training with weight-training machines after the intervention; 2) to examine whether or not resistance training with weight-training machines 1 or more days per week for 1 year after the intervention would change HRQOL in community-dwelling elderly.

## Methods

*Study design*

The study was a prospective 1-year follow-up to assess the continuation status of voluntary resistance training, a 12-week training program in which subjects were assigned to participate in the intervention with PRT and balance training.

*Participants*

Participants were 167 males and females without an exercise routine, aged 65 years and older living in Sapporo City, Naie Town, Takahama City, and Omuta City in Japan. They were recruited through a public relations magazine and invited by public health nurses at 4 public facilities between August 2000 and September 2002. All participants completed a health history questionnaire and were examined by a physician and physical therapist prior to being admitted into the investigation. Those who met the following criteria were excluded: (a) cerebrovascular or cardiovascular accidents within the last 6 months; (b) acute liver problems or the active phase of chronic hepatitis; (c) diabetic mellitus with a history of hypoglycemic attack or with fasting plasma glucose concentrations of 200 mg/dl or higher, or with complications such as retinopathy or neuropathy; (d) systolic blood pressure above 180 mmHg or diastolic blood pressure above 110 mmHg at rest; (e) diagnosis of heart disease, an orthopedic problem, or dementia made by a medical doctor and a recommendation by this doctor that the subject be excluded.

After the intervention, participants divided voluntarily into two groups. Group 1 (trained with weight-training machines, or TR) performed resistance training 1 or more days per week. Group 2 (detrained, or DT) returned to a free-living life style (similar to that before the training). Continuance of exercise for 1 year was confirmed by both the participants and the exercise instructor of each facility by direct interview. Most of those in the TR group had access to the same facility in which the intervention occurred, and they continued to exercise on their own. However a physical therapy instructor counseled them about exercise intensity and managed their activities safely according to individual need. Reasons that detraining occurred after the intervention included access to facilities being inconvenient, participants being too busy with housework, and a spouse with a deteriorating health condition. One person who resigned from training for private reasons during the T3 period is also included in the DT group.

All participants were evaluated for HRQOL before the program (T1), following 12 weeks of the program (T2), and after 1 year (T3) of resistance training 1 or more days per week or of free living. This study was conducted according to the Helsinki Declaration, and informed consent was obtained from all persons prior to their participation.

*Intervention program*

The intervention protocol for this study has been described in detail previously (Arai et al., 2007). Briefly, It consisted of a 3-month facility-based program involving PRT and balance training. This is designed to strengthen large muscle groups most important for functional activities and to improve balance capacity. Included in the activities are leg press, knee extension, hip abduction, and rowing (Proxomed, Germany). Participants were asked to train twice weekly for 1.5 hours (for a total of 24 training sessions), with each class consisting of 8–10 individuals under the direct supervision of a physical therapist, a trained exercise instructor, and a nurse.

A "conditioning phase," a "strengthening phase," and a "functional training phase" were incorporated into each month. The first phase was designed to condition physical functions through low-intensity exercise with high repetition. In this phase, participants learned proper forms, speed control, and a breathing technique. The second phase began at 60% of 1 Repetition Maximum (1 RM). 1 RM was defined as the maximum weight that could be lifted through a full range of motion with proper form. Evaluation of 1 RM was performed on the first day of the second phase. Weight was adjusted accordingly to ensure that the intensity was moderate to high. Resistance was increased if the participant was able to effortlessly complete three sets of ten repetitions. A rest of approximately 2 min, sometimes more, was given between sets of machine training. The third phase involved balance training such as stepping and walking on an unstable mat (Alusuisse Airex, Swiss), in addition to PRT. The tasks of balance and functional training progressively increased in difficulty on the basis of each individual's ability. Each training session consisted of 2 to 3 sets of 10 repetitions, and each session was preceded by warm-up and cool-down periods of 15 minutes that consisted of stretching the muscle groups involved in the strength training.

*HRQOL assessment*

HRQOL was measured using the Medical Outcomes Survey Short Form 36 (SF-36). The SF-36 results were analyzed using the following eight dimensions: Physical Functioning, Role Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role Emotional, and Mental Health. Scores ranged from 0–100, with a higher score reflecting a better QOL. This is a reliable and valid measure in community-dwelling elderly (Stewart et al., 1988) and in the general Japanese population (Fukuhara et al., 1998, 1998). Each dimension score was weighted in a three-step process to produce a standardized T-score (where the population mean

score was 50, SD=10). In this study, a score <50 means that the score representing the specific health concept was below that of the Japanese national norm after adjusting for age and sex.

*Statistical analysis*

Differences in the SF-36 were examined using a general linear model (two-way analysis of variance) with repeated measures. The dependent variables for both groups were compared over the three time points (T1, T2, and T3). A Bonferroni post hoc test was used to assess the differences found with the repeated measures analysis. Change between groups was assessed with an analysis of covariance (ANCOVA) model, where the dependent variables were T2 and T3 scores, the independent variable was group, and the covariate was the baseline score (T1). Statistical significance was set at the $p<.05$ level. Data were analyzed using SPSS 11.0J for Windows (SPSS, Inc., Chicago, IL).

## Results

*Attrition and continuance*

Participants' characteristics at T1 are presented in Table 1. One hundred fifty-three of 167 participants completed the exercise program. Fourteen (8.4%) dropped out in the exercise program period. Of these 14, 2 completed the program but were unable to come for T2 data collection. Another 12 dropped out because they became ill, suffered knee pain after field labor, or had a scheduling conflict. Among those who dropped out due to illness, their illness had no apparent relation to the training intervention.

Of the 153 participants who completed the exercise program, 135 attended T3 data collection. The 18 individuals who did not come for T3 data collection had scheduling conflicts, were ill, moved house, or died. The 32 who dropped out were not significantly different from the 135 who accomplished T3, based upon their baseline measurements.

*Persistence rate*

Of the 135 who attended the T3 follow-up, 77 (57.0%) were in DT, and the remaining 58 (43.0%) were in TR. The characteristics of both groups are summarized in Table 1. No significant differences by age or sex were observed.

*HRQOL*

The eight subscale scores for T1, T2, and T3 are shown in Table 2. At the T1, no subscale scores differed between groups. Scores for Physical Functioning (T2 and T3), Role Physical (T3), Vitality (T2), and Mental Health (T2) for the TR group increased ($p<.01$) over their corresponding T1 scores. In the DT group, Vitality and Mental Health increased (both $p<.01$) compared to T1 scores, while T3 scores for Physical Functioning, General Health, Vitality, and Mental Health decreased ($p<.05$–$p<.01$) from their corresponding T2 scores.

**Table 1** Baseline (T1) Sample Characteristics

| Characteristic | Total sample (N=167) | Sample who completed T3 measurement (N=135) | DT group (N=77) | TR group (N=58) |
|---|---|---|---|---|
| Age (years) | 74.0±4.9 | 73.9±5.1 | 74.6±5.0 | 73.1±5.0 |
| Gender (male/female) | 46/121 | 35/100 | 18/59 | 17/41 |
| Height (cm) | 151.6±8.5 | 151.9±8.2 | 152.0±8.7 | 151.6±7.6 |
| Weight (kg) | 55.0±9.1 | 55.3±9.1 | 56.4±9.6 | 53.8±8.4 |
| Maximum gait speed (m/min) | 94.2±28.6 | 94.2±28.9 | 93.8±30.6 | 94.8±26.9 |

Notes: No characteristics are significantly different between groups.
DT means detraining; TR means training at 1 year after T2.

**Table 2** The score of SF-36 subscales and the results of repeated two-way ANOVA, ANCOVA

| Variable | DT (n=77) | | | TR (n=58) | | | *p*-value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T1 | T2 | T3 | Group | Time | Interaction | T2 | T3 |
| Physical functioning | 47.8±10.3 | 49.1±10.7 | 47.0±10.4$^{\dagger}$ | 48.1±8.6 | 51.2±8.4* | 52.0±7.6$^{\S}$ | .003 | .000 | .001 | .043 | .000 |
| Role Physical | 48.9±10.4 | 50.2±9.9 | 47.7±10.5 | 47.0±10.3 | 50.3±10.7 | 51.0±9.4* | .034 | .071 | .030 | .612 | .015 |
| Bodily Pain | 49.1±9.7 | 51.3±8.8 | 47.4±9.7 | 49.3±9.2 | 51.0±8.5 | 50.4±10.0 | .133 | .005 | .113 | .784 | .069 |
| General Health | 49.4±7.3 | 50.1±7.2 | 47.7±8.2$^{\ddagger}$ | 48.2±7.8 | 50.3±8.8 | 49.8±8.9 | .061 | .013 | .037 | .376 | .029 |
| Vitality | 49.5±7.1 | 52.8±8.5$^{\S}$ | 48.3±9.4$^{\ddagger}$ | 48.3±8.4 | 52.7±8.3$^{\S}$ | 51.0±9.2 | .045 | .000 | .025 | .566 | .025 |
| Social Functioning | 51.0±7.9 | 50.6±9.3 | 50.2±9.2 | 50.5±8.2 | 53.2±7.6 | 51.6±8.2 | .196 | .391 | .189 | .095 | .279 |
| Role Emotional | 49.2±10.5 | 49.8±10.2 | 47.9±10.7 | 48.4±10.4 | 51.0±9.7 | 50.4±9.4 | .296 | .294 | .281 | .457 | .108 |
| Mental Health | 51.1±8.6 | 55.0±8.4$^{\S}$ | 48.9±8.7$^{\ddagger}$ | 49.8±7.0 | 54.3±8.0$^{\S}$ | 52.0±7.8 | .017 | .000 | .010 | .914 | .012 |

Notes: *: $p<.05$ compared with T1 , $^{\S}$: $p<.01$ compared with T1, $^{\dagger}$: $p<.05$ compared with T2, $^{\ddagger}$: $p<.01$ compared with T2 using ANOVA.
T2, T3 in the p-value column means the results of ANCOVA; the covariate is T1 scores.

There were, however, no subscale scores lower at T3 than at T1.

The results of ANCOVA also are shown in Table 2. The T2 scores, except for Physical Functioning, did not differ between groups. While in T3, Physical Functioning ($p<.01$), Role Physical ($p<.05$), General Health ($p<.05$), Vitality ($p<.05$), and Mental Health ($p<.05$), of the eight subscales in TR group, were significantly higher than those of the DT group.

In this study, subscale scores of SF-36 <50 mean that a specific health concept was lower than that of the normal Japanese population after adjusting for age and sex. At T1, subscale scores showed lower or near normal scores in both groups. At T2, all subscales of the TR group and six of the DT group exceeded 50. At T3, seven subscales of the TR group exceeded 50, while all subscales of the DT group decreased to less than 50.

## Discussion

The purpose of this investigation was to determine the persistence rate for voluntary resistance training using weight-training machines and to examine whether high-intensity resistance training for one or more days per week or free-living for 1 year could maintain or change HRQOL following 12 weeks of an exercise program. The results of the present study extend evidence supporting the efficacy of this program including PRT and balance training to enhance HRQOL in older adults. This is the first study to provide evidence of the efficacy of PRT and balance training for improving and maintaining HRQOL in community-dwelling older adults if they continue to exercise unsupervised after intervention.

The overall dropout rate (8.3%) for the 12-week program was comparable to that of previous studies focusing on home-based (McCool et al., 1999) resistance training (Binder et al., 2002) for older people or aerobic exercise (McAuley et al., 1995) for middle-aged people. This high compliance implies that the subjects enjoyed the exercise program, and also attests to the acceptable nature of resistance training with weight machines in older adults.

Adherence to an exercise program is a well-documented problem, with attrition rates of roughly 50% within the first 6 months (Dishman, 1990). One of the findings of this study was that approximately half of participants continued using weight-training machines voluntarily even 1 year after this program ended. This result suggests that training using weight-training machines may be more feasible for older adults to implement and maintain over the long term than other types of programs.

Other findings from the present study suggest that individuals who trained 1 or more days per week were able to maintain their scores on most subscales of the SF-36 for which they showed increased levels during this exercise program. Conversely, among those who did not participate in or who resigned from resistance training after 1 year, half of the eight subscales showed a decline after 1 year. In addition, differences between the groups increased as time from intervention passed.

Increases in HRQOL during the exercise program observed here are consistent with those observed in other studies of resistance training among older adults (Singh et al., 1997). However, T3 scores for Physical Functioning, General Health, Vitality, and Mental Health declined compared to T2 scores in the DT group. This result indicates that the HRQOL of the DT group, which improved during the intervention, became worse during the detraining period.

At T2, subscales had no significant differences between the groups except for Physical Functioning. However, five subscale scores showed significant differences between the groups at T3 using ANCOVA, indicating that differences increased over time due to lack of activity after the intervention even though there were no differences at T2.

Significantly higher scores compared to T1 for Physical Function and Role Physical were maintained in the TR group after 1 y. Therefore, maintaining exercise similar to that performed during the intervention may contribute to enhancing the HRQOL. More positive findings in the TR group may reflect social aspects of going out and the associated positive environment. Olney and colleagues (Olney et al., 2006) report that supervision or inclusion in a social group may play a supportive role. The home program may not have met participants' needs for social contact or for a sense of belonging (Helbostad et al., 2004). In this study, the DT group may have been in a situation similar to that in the earlier study; this group may have had less support and fewer social relations than the TR group after intervention.

It was possible for the HRQOL of participants to deteriorate, though not significantly, at T3 in comparison to T1. This result suggests the importance of the DT group making significant HRQOL gains during the intervention period. Compared with the normal Japanese population score, the DT group showed scores lower than 50 in seven subscales at T3, despite an improvement of more than 50 points at T2. On the other hand, the scores of TR improved more than 50 points in T2 and remained higher than those of the normal Japanese population in seven subscales.

One of the limitations of this study is that we had no randomized control group. Therefore, no conclusions can be drawn regarding the effects of a free-living life style without this exercise program on the parameters measured here. However, the DT group's change in score from T2 to T3 can at least partly illuminate the effects of not performing resistance training. Furthermore, this study shows the rate of exercise maintenance was dependent solely on the will of the participants. There was also the bias of a divided group because carrying out the exercise depended on the individual will of the subjects, possibly causing bias due to the lack of randomization of the groups. But there was at least no difference in the groups at the baseline. A previous study reported that self-efficacy predicts exercise behavior (McAuley, 1993). Therefore, further studies are needed to investigate the relationships between exercise maintenance and

HRQOL and self-efficacy.

The present study was a longitudinal study that included a relatively large sample size. Results suggest that a comprehensive exercise program can improve HRQOL of community-dwelling older adults. This program is very accessible and feasible for older adults to maintain over a long term. Maintenance of exercise habits could produce a higher HRQOL, but on the other hand, lack of exercise could cause individuals to return to their previous level of HRQOL as measured before the intervention. These findings have important social ramifications for the elderly population and for public health care.

**Acknowledgements** The authors wish to express sincere thanks to Toshiro Futami, Hiroko Sugawara, Makoto Seki, Kazuhiro Makino, and the all participants who cooperated with this study.

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Received: August 8, 2007
Accepted: November 26, 2007
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