Author(s): Kekäläinen, Tiia; Kokko, Katja; Tammelin, Tuija; Sipilä, Sarianna; Walker, Simon

Title: Motivational characteristics and resistance training in older adults : A randomized controlled trial and 1-year follow-up

Year: 2018

Version: Accepted version (Final draft)

Please cite the original version:

Kekäläinen, T., Kokko, K., Tammelin, T., Sipilä, S., & Walker, S. (2018). Motivational characteristics and resistance training in older adults : A randomized controlled trial and 1-year follow-up. Scandinavian Journal of Medicine and Science in Sports, 28(11), 2416-2426. https://doi.org/10.1111/sms.13236

MS TIIA KEKÄLÄINEN (Orcid ID : 0000-0003-0160-727X)

DR SIMON WALKER (Orcid ID : 0000-0002-6804-0741)

Article type : Original Article

Motivational characteristics and resistance training in older adults: a randomized controlled trial and 1-year follow-up

Running title: Motivation and resistance training

Authors:

Tiia Kekäläinen[1,2], Katja Kokko[1], Tuija Tammelin[3], Sarianna Sipilä[1], & Simon Walker[2]

[1]Gerontology Research Center and Faculty of Sport and Health Sciences, University of Jyväskylä, Finland

[2]Neuromuscular Research Center and Faculty of Sport and Health Sciences, University of Jyväskylä, Finland

[3]LIKES Research Centre for Physical Activity and Health, Finland

Corresponding author:

Tiia Kekäläinen

Viveca 146, Gerontology Research Center, PO Box 35

40014 University of Jyväskylä, Finland

tiia.m.kekalainen@jyu.fi

tel. +358408287501

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/sms.13236

Motivational characteristics and resistance training in older adults: a randomized controlled trial and 1-year follow-up

Abstract

The aim of this study was to investigate the effects of a nine-month supervised resistance training intervention on motivational and volitional characteristics related to exercise, and whether the absolute level and/or intervention-induced change in these characteristics predict self-directed continuation of resistance training one year after the intervention. Community-dwelling older adults aged 65-75, who did not fulfill physical activity recommendations, were randomized into resistance training intervention groups: training once- (n=26), twice- (n=27), three-times-a-week (n=28) or non-training control group (n=25). Training groups participated in supervised resistance training for nine months: during months 1-3 all groups trained twice-a-week and then with allocated frequencies during months 4-9. Exercise-related motivation, self-efficacy and planning were measured with questionnaires at baseline, month-3 and month-9. The continuance of resistance training was determined by interviews six and twelve months after the end of the intervention. The intervention improved action and coping planning as well as intrinsic motivation (group×time $p<.05$). During one-year follow-up, 54% of participants did not continue self-directed regular resistance training, 22% continued regular resistance training once-a-week and 24% twice-a-week. Increases in exercise self-efficacy and intrinsic motivation related to training during the intervention predicted continuation of resistance training twice-a-week. Resistance training improved exercise-related motivational and volitional characteristics in older adults. These improvements were linked to continuing resistance training one year after the supervised intervention. The role of these characteristics should be taken into account when promoting long-term resistance training participation among older adults.

Keywords: motivation, volition, strength training, exercise, physical activity, aging

INTRODUCTION

Regular and progressive resistance training (RT) offers major benefits to older adults' physical functioning and health, such as maintaining and increasing muscle mass, strength and power.[1-3] According to both the American College of Sport Medicine[4] and Finnish national physical activity recommendations,[5] older adults should participate in muscle-strengthening activities at least twice-a-week. However, in Finland, only 11% of older adults aged 65-74 report meeting these recommendations.[6] Hence, understanding the possible reasons for non-participation and participation in RT are important.

There are many theories explaining the potential psychological reasons for participating in exercise, and motivation is one of the key characteristics behind a behavior.[7,8] According to self-determination theory by Ryan and Deci,[8] motivation can arise from the satisfaction and pleasure of the activity itself (intrinsic motivation) or from extrinsic outcomes achieved via the activity (extrinsic motivation). Motivation is seen as a continuum from more extrinsic motivation to more intrinsic and autonomous motivation.[8] In the Health Action Process Approach (HAPA) by Schwarzer, motivation is distinguished from volition: the motivational phase leads to intention and secondly, the volitional phase leads to actual behavior.[9] In the volitional phase, implementing intentions is closely related to action planning, which includes planning when, where and how to exercise, as well as coping planning, which describes how difficult situations will be confronted.[9,10] Both of these have been shown to be predictors of exercise adherence.[11] In addition, self-efficacy is needed in both motivational and volitional phases.[9,12] Based on Bandura´s social cognitive theory, self-efficacy describes how confident an individual is about their abilities to succeed in different situations or tasks.[13] High self-efficacy is linked to commitment and intrinsic motivation.[13] Related to health-enhancing behavior, self-efficacy reflects, for instance, capabilities to perform an action and to overcome different barriers (coping self-efficacy).[9,12]

Although exercise-related motivational and volitional characteristics have been shown to be determinants of exercise participation,[11,14,15] much less is known specifically regarding RT. Winett et al.[16,17] suggest that RT may require a specific set of beliefs compared to other physical activities because of its nature. For example, confidence to lift external loads and increase the training-load regularly is a specific requirement in RT. Nevertheless, there is some evidence that exercise self-efficacy is also closely related to RT; exercise self-efficacy beliefs have been associated with the continuance of RT after intervention in older adults,[18] but not in all studies.[19]

Interestingly, there is some evidence that the association between motivational and volitional characteristics and RT may be bi-directional; these characteristics are related to adoption and continuance of physical activity, but also RT in itself may be able to improve these characteristics. For example, RT has had a positive effect on confidence to lift external loads in older adults [20] and on exercise self-efficacy in younger adults.[21] In addition, there is evidence that RT interventions lasting 12-week (three times-a-week) can improve introjected, identified and intrinsic motivation for exercise.[22,23] However, it is currently unclear whether RT training frequency influences these findings in older adults.

Therefore, the purpose of this study was to; 1) investigate the effects of a nine-month RT intervention with different training frequencies on exercise-related motivational and volitional characteristics, assessed here by motivation, self-efficacy, action and coping planning, and 2) investigate whether their absolute level and/or intervention-induced change predicted self-directed RT continuance one year after the intervention. Based on the review of the literature, it was hypothesized that RT will improve motivational and volitional characteristics in older adults and that higher levels of exercise motivation and self-efficacy predict RT continuance after the intervention. The present study was a secondary analysis of a randomized controlled trial “Get in Shape in the Team Research” (Clinical trials (clinicaltrials.gov) register number NCT02413112). Previous studies that have published the physical outcomes of the trial showed that maximum strength[24] and cardiorespiratory fitness[25] improved after 3 months of training, and a higher training frequency provided greater benefit for maximum dynamic strength, but not for functional capacity, over the 9–month intervention.[26]

METHODS

Study design and participants

This study was a secondary analysis of a parallel-group randomized controlled trial. Ethical approval for the study was obtained from the Ethical Committee of the University of Jyväskylä and all participants signed written informed consent prior to participation. The study design, participants and intervention have been described in detail in previous studies.[24,26] Participants were randomly assigned to four groups: RT once-a-week (RT1 n=26), RT twice-a-week (RT2 (n=27), RT three times-a-week (RT3 n=28) and non-training control group (CG, n=25). Pre-trial power analysis for primary outcomes of the study (maximum strength and functional capacity) was based on the effect sizes reported in a meta-analysis by Liu and Latham.[1] With a 75:25 intervention-to-control ratio, a sample size of 60 for strength and 88 for functional capacity was sufficient to reach 80% probability to observe treatment difference with a 5% level of significance.

The flow diagram of the study is shown in Figure 1. Participants were selected by random sampling from a population register of community-dwelling older adults aged 65-75 living in the Jyväskylä area. Recruitment occurred in October-December 2014. Inclusion criteria were; 1) leisure-time aerobic exercise less than 3 hours/week, 2) no previous regular RT experience, 3) BMI<37, 4) no previous testosterone-altering treatment, 5) no serious cardiovascular disease that may affect participating in RT, 6) no medication related to the neuromuscular or endocrine systems, 7) capability to walk without walking aids and 8) no smoking. Two thousand invitation letters were sent with a response rate of 23% (n=454). Those who met the inclusion criteria (n=148) were invited to an information session and 116 participants attended a physician's examination: eight persons were excluded because of medical reasons and two persons were not interested in participating. Hence, 106 participants remained for randomization. Randomization and allocation were made by the principal investigator of the study who was not involved in data collection. Randomization was performed by an online random number generator in a block of 100 participants for four groups, 25 participants for each. Because it was assumed that higher training frequency is likely to increase non-compliance and drop-out rates, three participants were randomized to RT3, two to RT2 and one to RT1 from the remaining six participants. Two participants dropped out from CG because of the randomization result.

Intervention

Training groups (RT1, RT2, and RT3) participated in a nine-month supervised whole-body RT intervention at the Faculty of Sport and Health Sciences gym, University of Jyväskylä. The exact training program has been previously reported[24,26], but briefly, each one hour training session included a 10-min warm-up and 8-9 exercises for different muscle groups (e.g. leg press, knee extension and flexion, chest press, pulldown, pushdown, pec deck, ab crunch. back extension) and was supervised by trained personnel. All training groups followed an alternating two-session training program throughout the intervention. *Months 1-3:* To become familiar with RT and to build capacity for high-load RT, all training groups (RT1, RT2 and RT3) participated in supervised RT twice-a-week for the first three months. The focus of this initial period was on muscular endurance using low loads, with participants performing 2-3 sets of 14-20 repetitions with 0- to 1-min rest between sets for each exercise. *Months 4-9:* The training groups started to exercise with different frequencies: completing the two-session program took two weeks from RT1, one week from RT2 and RT3 completed three cycles in two weeks. The frequency-specific 6-month training period focused on developing muscle hypertrophy and maximum strength. The participants performed 4-5 sets of 4-12 repetitions with 1-3 minutes rest between sets. CG was instructed not to change their lifestyle during the intervention and after month-9 measurements they had an opportunity to participate in supervised RT twice-a-week for six months.

After the nine-month intervention, participants of the training groups could no longer train in the same gym as during the intervention and had to arrange possible continuance of training by themselves. To lower the threshold to continue training independently, participants were given a list of possible low-cost gyms in the city area from the principal investigator upon completion of the month-9 tests.

Measurements

Motivational and volitional characteristics were measured with computer-based questionnaires related to exercise or physical activity in general (not specifically RT).

Exercise self-efficacy was measured by ten questions developed by Schwarzer: five questions evaluated action and coping self-efficacy [12] and five questions barrier self-efficacy.[27] These scales have satisfactory psychometric properties [12,27] and have been used among Finnish adults and older adults.[28,29] Participants were asked to evaluate how confident they were to maintain exercise in different situations related to adoption (e.g. "even if I have to make a detailed plan to exercise") and to overcome barriers (e.g. "even when I am busy"). The answers were given on a scale from 1 = *very certain I cannot* to 4 = *very certain I can*, and aggregated. Cronbach´s alphas were .91, .92 and .92 at baseline, month-3, and month-9, respectively.

Action planning and coping planning to exercise were both assessed with four questions.[10] Participants were asked whether they had a detailed plan when, where, how and how often to exercise (action planning) and how to combat the different barriers and obstacles to exercise (coping planning). The scale was from 1 = *not at all true* to 4 = *very true*. The scale has good psychometric properties in a wide population age range.[10] Cronbach´s alphas were .89, .90 and .89 for action planning and .90, .91 and .86 for coping planning at baseline, month-3 and month-9, respectively.

Motivation for physical activity and training was measured with the Exercise Self-Regulation Questionnaire (SRQ-E).[30] The questionnaire has shown adequate psychometric properties among different populations.[31-33] The questionnaire has two parts: 16 statements measure motivation regarding physical activity (e.g. "I try, or would like to try, to be physically active regularly because I enjoy physical activities") and 12 statements regarding training (e.g. "I exercise/work out (or would like to work out) because I feel pressure to work out"). The scale was from 1 = *not at all true* to 7 = *very true*. The mean scores for each motivational regulation (external, introjected, identified and intrinsic) were calculated separately for physical activity and training. Cronbach´s alphas showed an adequate fit[34] (range .70-.92) to all four regulation styles for physical activity and to three regulation styles for training. The exception was introjected regulation for training: Cronbach´s alphas were .47 at baseline, .57 at month-3 and .39 at month-9. The three items measuring introjected regulation for training were "I exercise/work out because I would feel bad about myself if I didn´t do it", …"I'd be afraid of falling too far out of shape if I didn't" and …"I feel pressured to work out". Deleting any of these items would not have improved alpha levels.

Leisure-time aerobic exercise was estimated at baseline by a single question specifying the average weekly minutes participants engaged in leisure-time aerobic exercise. During the intervention, diaries tracked daily activities, as well as the duration and intensity of the activities recorded.[35] The average weekly minutes for leisure-time aerobic exercise for months 1-3 and 4-9 were calculated from the diaries.

Continuance of RT: In interviews six months after the intervention ("follow-up 1") and 12 months after the intervention ("follow-up 2"), participants were asked whether they had continued RT. At follow-up 1, the interviews were conducted face-to-face to all training group participants who participated in follow-up strength and functional capacity measurements (n=66). At follow-up 2, interviews were conducted by telephone from all training group participants except the two drop-outs and one participant (from RT3) who was not reachable (n=78). From those who had continued RT, the regularity and average number of RT sessions per ordinary week was asked (common short breaks e.g. because of flu or travel should not be taken into account) in both interviews. Training either individually or in a supervised group was accepted. The average weekly frequency to participate in RT during the year was calculated from values reported in follow-up 1 and follow-up 2. Those who reported that they had continued RT regularly during the year and at least six months twice-a-week and during the other six months once to twice-a-week (average for the year 1.75-2.5 times-a-week) were categorized as twice-a-week continuers. The cut-off value of 1.75 was used because these participants intended to participate in RT twice-a-week (and mostly achieved their intention) but there were some weeks when they trained only once-a-week due to holiday/illness or some other reason. Those who reported that they had continued RT regularly during the year at least once-a-week but not twice-a-week throughout the year (average for the year 1-1.5 times-a-week) were classified as once-a-week continuers. All others, including both participants who had not continued RT at all and participants who had continued less than once-a-week on average (e.g. some participants reported training approx. once-a-month), were classified as non-continuers.

Statistical analysis

Analyses were performed using IBM SPSS Statistics 24.0. A significance level of $p<.05$ was used in all analyses. The first study aim, to investigate the effects of intervention on motivational and volitional characteristics was analyzed by an intention-to-treat principle, with the exception of the two participants that dropped-out immediately after the randomization before baseline measurements for motivational and volitional characteristics. The differences between groups at baseline were analyzed by one-way ANOVA for continuous variables and Chi-Square test for categorical variables. The generalized estimation equation (GEE)–method with an unstructured working correlation matrix was used to analyze group×time differences between groups. Based on the structure of the intervention, three sets of GEE analyses were performed; 1) baseline – month-3 between CG and the training group (RT1, RT2 and RT3), 2) month-3 – month-9, and 3) baseline – month-9 between CG, RT1, RT2 and RT3. Because the amount of leisure-time aerobic exercise (min/week) was not stable in all groups during the intervention (assessed by physical activity diaries), GEE analyses were repeated and adjusted for the amount of leisure-time aerobic exercise. The diaries were missing from seven participants (1 from each RT group and 4 from CG), hence those participants were excluded from the adjusted analyses. The results of analyses with and without aerobic exercise adjustment were similar, therefore only the adjusted GEE results are shown in the Results section. In addition to GEE analyses, the standardized effect sizes for differences in change-scores between groups were calculated with Cohen´s *d* formula.[36] The changes in motivational and volitional characteristics during the intervention were calculated by subtracting the baseline value from the intervention completion (month-9) value. Within-group differences were analyzed by paired sample t-tests.

The second study aim was to investigate predictors of continuing RT after the intervention. Both the absolute level at post-intervention (month-9) and change during the intervention (month-9 value – baseline value) of motivational and volitional characteristics were analyzed as possible predictors. Differences in possible predictors between non-continuers, once-a-week continuers and twice-a-week continuers were analyzed by one-way ANOVA and Chi-Square tests.

RESULTS

Descriptive statistics

The flow of the participants throughout the study is shown in Figure 1. Three participants dropped out from CG, one from RT1 and one from RT2 (Fig 1).The dropout from RT1 was due to back pain induced by the strength testing in month-6, and other drop-outs occurred due to health (acid reflux events, stress-related high blood pressure, cancer recurrence) or personal issues unrelated to the study.

There were some adverse event, as judged by the investigators, in the study. Adverse effects were collected by self-reports: participants reported more serious ones directly to the principal investigator and documented minor ones in their training diaries. The most serious adverse event was the back pain induced by the strength testing. One participant strained a hamstring muscle walking home after strength measurements at month-3 and could continue the training program but no longer participate in maximum muscle strength measurements. Based on information collected from training diaries, about one third of the participants in training groups had some temporary pain or soreness, for example, in the knee joint, shoulder or back. For these participants the training program was adjusted (e.g. use of lighter loads, modified exercise technique) for a maximum of 2-3 weeks. These discomforts were judged to be part of the adaptation processes, and indeed these feelings were short-term and did not adversely affect participation rates during the 9-month intervention period.

During the first three months of intervention, the training adherence was 97%±4 (range 88-100). [24] During months 4-9, mean adherences were 97%±5 (range 79-100) in RT1, 97%±5 (79-100) in RT2 and 94%±7 (75-100) in RT3. There were no statistically significant differences between groups in adherence rates.

Participants' demographic characteristics and baseline values in motivational and volitional characteristics are presented in **Table 1.** The only significant difference between groups at baseline was in coping planning (ANOVA F(df)=3.30(3), p=.024), which had a higher value in RT1 compared to RT3.

Changes in exercise-related motivational and volitional characteristics during the intervention

The effects of the intervention on motivational and volitional characteristics are presented in **Table 2 and 3.** After three months intervention, there were significant group×time effects for exercise self-efficacy, action and coping planning and intrinsic motivation related to training. From month-3 to month-9 there were no statistically significant between-group differences. Throughout the nine-month intervention, changes occurred in several measured motivational and volitional characteristics. Action planning improved in all training groups compared to CG. Coping planning and intrinsic motivation related to physical activity improved in RT2 and RT3 compared to CG. Both RT2 and RT3 increased their intrinsic motivation related to training and RT2 also introjected regulation related to physical activity compared to CG and RT1. The changes in these variables are shown in **Figure 2**.

Predictors of RT continuance

Of 78 participants, 31 (40%) reported that they did not continue RT at all after the intervention. Five persons (6%) continued RT immediately after the intervention but quit prior to follow-up 1 (6 months after the intervention) and six persons continued RT occasionally (less than once-a-week on average) throughout follow-up (12 months). Therefore, 42 persons (54%) were counted as non-continuers. Seventeen persons (22%) reported to have trained regularly once-a-week on average during the whole year and 19 persons (24%) twice-a-week on average. The average weekly frequency to participate in RT varied between 1.0–2.5 (mean 1.58, SD 0.48). There were no significant differences between intervention groups in continuance rates (Table 4).

The level of motivational and volitional characteristics at post-intervention (month-9) and their change during the intervention (baseline to month-9) were analyzed as possible predictors for continuance of RT (**Table 4**). Twice-a-week continuers had a greater increase in exercise self-efficacy during the intervention than non-continuers and a greater increase in intrinsic motivation related to training compared to both non-continuers and once-a-week continuers.

DISCUSSION

The purpose of this study was to 1) investigate the effects of a RT intervention with the different training frequencies on exercise-related motivational and volitional characteristics, and 2) whether the absolute level and/or change in these characteristics predict self-directed continuance of RT one year after the intervention. RT led to positive changes in exercise self-efficacy, planning and autonomous motivation. Twenty-two percent of participants continued regular RT once-a-week and 24% twice-a-week during the next year after the intervention. A greater increase in exercise self-efficacy and intrinsic motivation related to training during the intervention predicted continuation of RT twice-a-week during follow-up.

The effect of RT on exercise self-efficacy and motivation is in-line with previous studies [20-23,37], indicating that participation in RT intervention can increase self-confidence to maintain exercise behavior and increase intrinsic motivation to exercise in addition to physical outcomes. However, the improvements in exercise self-efficacy diminished after three months in the present study. It is plausible that at month-3 measurements participants were more confident because the intervention was going to continue but at post-measurements they had started to think about training independently.[38] Action and coping planning in relation to RT have not been studied previously, but the results of the present study suggest that participating in a RT intervention can also increase exercise planning. In relation to motivation, a limitation of this study was that the scale for introjected regulation for training had low internal consistency (alpha values .39-.57). Low alpha reliability implies that the items intended to measure introjected regulation do not measure it in a consistent way in this study sample, even though the scale has had good psychometric properties in previous studies. [31-33] Therefore, the results for introjected regulation for training should be treated with extreme caution.

A possible source for exercise motivation could be the improvements in strength and functional capacity during the intervention.[24-26] However, in the present study, improvements in strength and functional capacity did not influence changes in motivational and volitional characteristics (tested in GEE-analyses adjusted by change in strength and functional capacity, the results not included in the paper). In addition, other characteristics of the intervention may have affected the results. For instance, training in small groups (8-10 persons) and having support/encouragement from the research staff may have affected motivational and volitional characteristics. Hence, even though RT interventions seem to be an effective way to increase intrinsic motivation and planning, it is not clear whether performing RT itself (i.e. without these potential confounding factors) led to these findings. To examine this, the relationship between RT and these characteristics should be studied external to a structured scientific, group-based intervention.

When comparing the results between different training frequencies, there were no differences between groups from month-3 to month-9. It should be noticed, however, that when comparing month-9 results to baseline, RT1 only improved their action planning compared to CG, whereas RT2 and RT3 improved also coping planning and intrinsic motivation related to both physical activity and training. Furthermore, RT2 and RT3 improved their intrinsic motivation related to training also compared to RT1. In support of these findings, effect sizes suggest that training twice- or three times-a-week was related to greater changes in these characteristics over the entire intervention period. It is likely that the structure of the intervention influenced these findings and should be remembered when interpreting the results: all training groups participated in RT twice-a-week during the first three months and then split into different frequencies. This meant that the once-a-week group were forced to reduce their training frequency. Therefore, it is not possible to separate the effects of training frequency per se from the effects of reducing training frequency. In future studies, it should further be investigated whether it is the recommended RT frequency of at least twice-a-week [4] to derive also the most motivational benefits. However, our results suggest that greater resistance training frequency contributes little to improved motivational and volitional characteristics since we did not observed differences from month-3 to month-9 measurements.

Almost half of the participants (46%) continued RT during the one-year follow-up at least once-a-week. The continuation rate is similar to the studies by Geirsdottir et al. [39], in which ~18% of participants continued RT once- or twice-a-week and ~24% ≥three times-a-week, and Inaba et al. [40], in which 43% continued RT at least once-a-week. In both studies the continuation was measured by self-reports. A limitation of the present study is that participants were not able to continue RT in the same gym used during the intervention. Finding a new place to continue RT could have been a significant barrier for some participants and reduced the continuance rates. In any case, it is a positive finding that almost half of the participants continued training at least once-a-week, since even participating in RT only once-a-week leads to important physical improvements for older individuals compared to not participating at all.[26,41] However, another limitation of this study is that the continuance frequencies are based on self-reports and information about participants´ actual gym visits was not available. For example, Van Roie et al.[42] obtained information regarding gym visits from the fitness center and found that only 20% of participants continued RT during a 4-month follow-up and none of them met the recommended twice-a-week frequency. However, even though self-reports may both over- or underestimate the actual amount of physical activity,[43] even a single question could be a useful method to estimate physical activity.[44]

The present study provided some interesting findings regarding motivational and volitional characteristics and RT continuation. Firstly, contrary to previous research,[15,18] the level of the characteristics was not related to RT continuation. A possible reason for that could be that the participants of this study had relatively high values in these characteristics already at baseline (e.g. compared to a sample of younger physically inactive Finnish adults[28]). In addition, it is possible that participants may have had high motivation for exercise in general but they preferred physical activities other than RT. This may not have been observable in the present study because the measurements used were related to non-specific physical activity or exercise. Indeed, when exercise preferences were asked from participants at follow-up 2, over half of them mentioned some type of aerobic exercise and only 16% mentioned RT as their favorite type of exercise. Unfortunately, the information about frequency to participate in other physical activities during the follow-up period was not gathered in the present study.

Secondly, increases in exercise self-efficacy and intrinsic motivation related to training during the intervention were related to continuance of RT during follow-up. Individuals with high exercise self-efficacy have better strategies and are ready to put more effort on exercising and overcoming barriers. It is possible that during regular participation in RT for nine months, some participants realized that they could overcome the potential barriers and that contributed to continuing RT also after the intervention. This finding supports the results of previous studies in relation to self-efficacy change and exercise continuance.[18,45] Regarding intrinsic motivation, it is possible that simply those who enjoy RT continued training after the intervention. Thirdly, there were differences only between twice-a-week continuers and non-continuers, not between once-a-week continuers and non-continuers. Moreover, twice-a-week continuers had greater increases in intrinsic motivation also compared to once-a-week continuers. This is an important finding for future studies to investigate because RT twice-a-week is superior to once-a-week for strength gains.[46] According to the results of the presents study, it can be suggested that by improving motivational and volitional characteristics related to exercise it could be possible to also increase RT participation. It has been shown that RT programs with behavioral counselling are more effective for the adoption of RT and exercise self-efficacy than basic programs including only exercise.[47,48] Therefore, physical activity interventions should also aim to improve these characteristics in order to promote the continuance of behavior after the intervention.

When generalizing the results of this study, it should be taken into account that first, only 23% of the original random sample replied to the invitation letters. As mentioned above, it is possible that the study sample was already highly motivated to participate in exercise/RT. Secondly, the sample consisted of healthy older adults aged 65–75 who did not meet the physical activity guidelines for either leisure time aerobic exercise or RT at baseline. Therefore, the results may not necessarily be generalized to different patient groups, all ages or more physically active individuals. It should be noted that the amount of leisure time aerobic exercise and RT background at baseline were measured with single questions, thus the information about specific exercise patterns before the intervention is not available. Thirdly, as a secondary analysis of a randomized controlled trial, this study may have been unpowered to detect differences in motivational and volitional characteristics with this sample size.

Perspectives

As resistance training is beneficial and recommended for older adults [1-4], but only a minority regularly participate (~10%) in it,[6] it is essential to identify ways to promote participation in resistance training activities. The present study showed that a resistance training intervention can improve exercise-related motivational and volitional characteristics and these improvements were related to continuing self-directed resistance training after the intervention. Therefore, if interventions can target and improve exercise motivation and self-efficacy, then it may be possible to increase participation rates in regular resistance training in healthy older populations.

Acknowledgements

This work was supported by a personal grant to Simon Walker from the Ministry of Education and Culture of Finland (OKM/56/626/2014). The authors declare that there is no conflict of interest.

References

1. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. *Cochrane Database Syst Rev*. 2009;3(3):CD002759.

2. Latham NK, Bennett DA, Stretton CM, Anderson CS. Systematic review of progressive resistance strength training in older adults. *J Gerontol A-Biol*. 2004;59(1):48-61.

3. Hunter GR, McCarthy JP, Bamman MM. Effects of resistance training on older adults. *Sports Med*. 2004;34(5):329-348.

4. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sport Exer*. 2009;41(7):1510.

5. UKK-instituutti. Terveysliikunnan suositukset: Viikoittainen liikuntapiirakka yli 65-vuotiaille [Recommendations for health-enhancing physical activity for older adults 65+: Weekly physical activity pie]. http://www.ukkinstituutti.fi/liikuntapiirakka/liikuntapiirakka-

_yli_65-vuotiaille. 2014. Accessed February 27, 2018.

6. Bennie JA, Pedisic Z, Suni JH, et al. Self-reported health-enhancing physical activity recommendation adherence among 64,380 Finnish adults. *Scand J Med Sci Sports*. 2017;27(12):1842-1853.

7. Standage M, Ryan RM. Self-determination theory and exercise motivation: Facilitating self-regulatory processes to support and maintain health and well-being. In: Roberts GC, Treasure DC, eds. Advances in motivation in sport and exercise. Champaign, IL: Human Kinetics.; 2012:233-270.

8. Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am Psychol*. 2000;55(1):68-78.

9. Schwarzer R. Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Appl Psychol Int Rev*. 2008;57(1):1-29.

10. Sniehotta FF, Schwarzer R, Scholz U, Schüz B. Action planning and coping planning for long-term lifestyle change: Theory and assessment. *Eur J Soc Psychol*. 2005;35(4):565-576.

11. Sniehotta FF, Scholz U, Schwarzer R. Action plans and coping plans for physical exercise: A longitudinal intervention study in cardiac rehabilitation. *Brit J Health Psych*. 2006;11(1):23-37.

12. Schwarzer R, Renner B. Social-cognitive predictors of health behavior. *Health Psychol*. 2000;19(5):487-495.

13. Bandura A. Self-efficacy. In: Ramachaudran VS, ed. Encyclopedia of human behavior. New York, NY, US: Academic Press; 1994:71-81.

14. McAuley E, Blissmer B. Self-efficacy determinants and consequences of physical activity. *Exerc Sport Sci Rev*. 2000;28(2):85-88.

15. Teixeira PJ, Carraça EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: A systematic review. *Int J Behav Nutr Phy*. 2012;9(1):78-107.

16. Winett RA, Williams DM, Davy BM. Initiating and maintaining resistance training in older adults: A social cognitive theory-based approach. *Brit J Sport Med*. 2009;43(2):114-119.

17. Winett R, Davy B, Savla J, et al. Theory-based approach for maintaining resistance training in older adults with prediabetes: Adherence, barriers, self-regulation strategies, treatment fidelity, costs. *Behav Med Pract Policy Res*. 2015;5(2):149-159.

18. Neupert SD, Lachman ME, Whitbourne SB. Exercise self-efficacy and control beliefs predict exercise behavior after an exercise intervention for older adults. *J Aging Phys Act*. 2009;17(1):1-16.

19. Van Roie E, Bautmans I, Coudyzer W, Boen F, Delecluse C. Low- and high-resistance exercise: Long-term adherence and motivation among older adults. *Gerontology*. 2015;61(6):551-560.

20. Katula JA, Rejeski WJ, Marsh AP. Enhancing quality of life in older adults: A comparison of muscular strength and power training. *Health Qual Life Out*. 2008;6(1):45-52.

21. LeCheminant JD, Hinman T, Pratt KB, et al. Effect of resistance training on body composition, self-efficacy, depression, and activity in postpartum women. *Scand J Med Sci Spor*. 2014;24(2):414-421.

22. Milne H, Wallman K, Gordon S, Courneya K. Impact of a combined resistance and aerobic exercise program on motivational variables in breast cancer survivors: A randomized controlled trial. *Ann Behav Med*. 2008;36(2):158-166.

23. Heiestad H, Rustaden AM, Bø K, Haakstad LAH. Effect of regular resistance training on motivation, self-perceived health, and quality of life in previously inactive overweight women: A randomized, controlled trial. *Biomed Res Int*. 2016;2016:3815976.

24. Walker S, Haff GG, Häkkinen K, Newton RU. Moderate-load muscular endurance strength training did not improve peak power or functional capacity in older men and women. *Front Physiol*. 2017;8:743.

25. Fernandez-Lezaun E, Schumann M, Makinen T, Kyrolainen H, Walker S. Effects of resistance training frequency on cardiorespiratory fitness in older men and women during intervention and follow-up. *Exp Gerontol*. 2017;95:44-53.

26. Turpela M, Hakkinen K, Haff GG, Walker S. Effects of different strength training frequencies on maximum strength, body composition and functional capacity in healthy older individuals. *Exp Gerontol*. 2017;98:13-21.

27. Schwarzer R, Renner B. Health-specific self-efficacy scales. https://userpage.fu-berlin.de/health/healself.pdf 2009. Accessed February 27, 2018.

28. Kangasniemi AM, Lappalainen R, Kankaanpää A, Tolvanen A, Tammelin T. Towards a physically more active lifestyle based on one's own values: The results of a randomized controlled trial among physically inactive adults. *BMC Public Health*. 2015;15(1):260-273.

29. Hankonen N, Absetz P, Ghisletta P, Renner B, Uutela A. Gender differences in social cognitive determinants of exercise adoption. *Psychol Health*. 2010;25(1):55-69.

30. Deci EL, Ryan RM. "Exercise self-regulation questionnaires". Self-determination theory: An approach to human motivation and personality - the self-regulation questionnaires. http://selfdeterminationtheory.org/self-regulation-questionnaires/. 2004. Accessed February 27, 2018.

31. Silva MN, Markland D, Vieira PN, et al. Helping overweight women become more active: Need support and motivational regulations for different forms of physical activity. *Psychol Sport Exerc*. 2010;11(6):591-601.

32. Levesque CS, Williams GC, Elliot D, Pickering MA, Bodenhamer B, Finley PJ. Validating the theoretical structure of the treatment self-regulation questionnaire (TSRQ) across three different health behaviors. *Health Educ Res*. 2007;22(5):691-702.

33. Nurmi J, Hagger MS, Haukkala A, Araújo-Soares V, Hankonen N. Relations between autonomous motivation and leisure-time physical activity participation: The mediating role of self-regulation techniques. *J Sport Exercise Psy*. 2016;38(2):128-137.

34. Tavakol M, Dennick R. Making sense of Cronbach's alpha. *Int J Med Educ*. 2011;2:53-55.

35. Waller B, Munukka M, Multanen J, et al. Effects of a progressive aquatic resistance exercise program on the biochemical composition and morphology of cartilage in women with mild knee osteoarthritis: Protocol for a randomised controlled trial. *Bmc Musculoskel Dis*. 2013;14(1):82.

36. Cohen J. A power primer. *Psychol Bull*. 1992;112(1):155-159.

37. Rhodes RE, Lubans DR, Karunamuni N, Kennedy S, Plotnikoff R. Factors associated with participation in resistance training: A systematic review. *Br J Sports Med*. 2017;51(20):1466-1472.

38. McAuley E, Jerome GJ, Elavsky S, Marquez DX, Ramsey SN. Predicting long-term maintenance of physical activity in older adults. *Prev Med*. 2003;37(2):110-118.

39. Geirsdottir OG, Arnarson A, Ramel A, Briem K, Jonsson PV, Thorsdottir I. Muscular strength and physical function in elderly adults 6–18 months after a 12-week resistance exercise program. *Scand J Public Healt*. 2015;43(1):76-82.

40. Inaba Y, Obuchi S, Arai T, Satake K, Takahira N. The long-term effects of progressive resistance training on health-related quality in older adults. *J Physiol Anthropol*. 2008;27(2):57-61.

41. Taaffe DR, Duret C, Wheeler S, Marcus R. Once-weekly resistance exercise improves muscle strength and neuromuscular performance in older adults. *J Am Geriatr Soc*. 1999;47(10):1208-1214.

42. Van Roie E, Bautmans I, Coudyzer W, Boen F, Delecluse C. Low- and high-resistance exercise: Long-term adherence and motivation among older adults. *Gerontology*. 2015;61(6):551-560.

43. Prince SA, Adamo KB, Hamel ME, Hardt J, Connor Gorber S, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *Int J Behav Nutr Phy*. 2008;5(1):56.

44. Portegijs E, Sipilä S, Viljanen A, Rantakokko M, Rantanen T. Validity of a single question to assess habitual physical activity of community-dwelling older people. *Scand J Med Sci Spor*. 2017;27(11):1423-1430.

45. Baruth M, Wilcox S. Predictors of physical activity 6 months postintervention in the active for life initiative. *J Phys Act Health*. 2014;11(2):256-265.

46. Ratamess NA, Housh TJ, Alvar BA, et al. Progression models in resistance training for healthy adults. *Med Sci Sport Exer*. 2009;41(3):687-708.

47. Teychenne M, Ball K, Salmon J, et al. Adoption and maintenance of gym-based strength training in the community setting in adults with excess weight or type 2 diabetes: A randomized controlled trial. *Int J Behav Nutr Phy*. 2015;12:105-113.

48. Katula JA, Sipe M, Rejeski WJ, Focht BC. Strength training in older adults: An empowering intervention. *Med Sci Sport Exer*. 2006;38(1):106-111.

Table 1. Participants´ demographic, motivational and volitional characteristics at baseline. Mean values with standard deviations in parentheses or frequencies presented.

	CG (n=23)	RT 1 (n=26)	RT 2 (n=27)	RT 3 (n=28)	p[a]
Gender: female %	47.8	53.8	59.6	57.1	.864
Education %					.091
Basic education	30.4	32.0	15.4	53.6	
Upper secondary education	21.7	32.0	42.3	25.0	
Tertiary education	47.8	36.0	42.3	21.4	
Age, y	68.3 (2.3)	68.9 (2.7)	67.7 (2.8)	69.0 (3.3)	.282
BMI, kg/m^2	26.4 (2.6)	27.3 (3.3)	28.6 (4.4)	29.0 (4.1)	.070
Aerobic exercise, min/week	110 (63)	113 (64)	111 (56)	85 (58)	.143
Exercise self-efficacy [10-40]	31.7 (3.2)	32.0 (4.5)	31.4 (5.5)	31.8 (4.0)	.967
Action planning [4-16]	11.4 (2.2)	11.6 (2.8)	10.5 (3.0)	10.6 (2.7)	.374
Coping planning [4-16]	10.8 (2.8)	11.0 (2.7)	10.3 (2.7)	8.9 (2.7)	.024 (1>3)
PA: External [1-7]	2.2 (1.0)	2.8 (1.8)	2.0 (1.0)	2.4 (1.3)	.136
PA: Introjected [1-7]	4.0 (1.2)	4.5 (1.4)	3.7 (1.1)	4.0 (1.4)	.184
PA: Identified. [1-7]	6.0 (0.9)	6.2 (0.8)	6.3 (0.7)	6.0 (0.9)	.661
PA: Intrinsic [1-7]	5.6 (1.2)	5.8 (1.1)	5.7 (1.0)	5.8 (1.1)	.904
TR: External [1-7]	3.4 (1.5)	4.0 (1.8)	3.7 (1.9)	3.4 (1.7)	.525
TR: Introjected. [1-7]	4.1 (0.8)	4.5 (1.3)	4.3 (1.1)	4.3 (1.0)	.757
TR: Identified. [1-7]	5.9 (1.1)	6.1 (0.9)	6.2 (0.8)	5.9 (1.1)	.684
TR: Intrinsic [1-7]	5.4 (1.4)	5.7 (1.2)	5.6 (1.0)	5.3 (1.3)	.757

[a]Differences between groups tested by one-way ANOVA for continuous variables and Chi-Square test for categorical variables. CG=control group, RT1-3=resistance training 1, 2 or 3 times/week groups, PA = motivational regulation related to physical activity, TR = motivational regulation related to training.

Table 2. Effect of the intervention on motivational and volitional characteristics, analyzed by generalized estimated equations (GEE). p-values presented.

	GEE model months 1-3[a]			GEE model months 3-9[b]			GEE model months 0-9[c]		
	Group	Time	Group× time	Group	Time	Group× time	Group	Time	Group× time
Self-efficacy	.246	.325	**<.001**	.234	**.004**	.136	.934	.094	.265
Action plan.	.986	**.005**	**.006**	.253	.857	.678	.775	**<.001**	**<.001**[d]
Coping plan.	.983	.275	**.010**	.167	**.041**	.397	**.045**	**.001**	**.012**[e]
PA:External	.472	.298	.283	.721	.995	.174	.356	.133	.136
PA:Introjected	.211	.778	.296	.753	.653	.203	.691	.348	**.025**[f]
PA:Identified	.680	.175	.133	.823	.973	.381	.593	.253	.087
PA:Intrinsic	.868	.638	.255	.885	.435	.100	.960	.832	**.030**[g]
TR:External.	.747	**.002**	.125	.829	.608	.139	.647	**.002**	.380
TR:Introjected	.688	.146	.379	.816	.782	.069	.928	**<.001**	.998
TR:Identified	.991	.303	.064	.829	.852	.464	.714	.654	.281
TR:Intrinsic	.873	.998	**.007**	.541	.794	.215	.891	.277	**<.001**[h]

Models adjusted by mean aerobic exercise (min/week) from [a]months 1-3, [b]months 3-9 and [c]months 1-9. PA = motivational regulation related to physical activity, TR = motivational regulation related to training. Significant differences between [d]CG vs. RT1 p=.019, CG vs. RT2 p<.001, CG vs. RT3 p<.001; [e]CG vs. RT2 p=.010, CG vs. RT3 p=.001; [f]CG vs. RT2 p=.026; RT1 vs. RT2 p=.004; [g]CG vs. RT2 p=.013, CG vs. RT3 p=.009; [h]CG vs. RT2 p=.008, CG vs. RT3 p<.001, RT1 vs. RT2 p=.047, RT1 vs. RT3 p=.003.

Table 3. Means and standard deviations (SD) in motivational and volitional characteristics at baseline, month-3 and month-9, and effect sizes (Cohen´s *d*) for mean changes between the groups.

	Baseline Mean(SD)	Month-3 Mean(SD)	Month-9 Mean(SD)	ΔEffect size (95%CI) 1-3	ΔEffect size (95%CI) 3-9	ΔEffect size (95%CI) 0-9
Self-efficacy						
CG	31.7 (3.2)	30.5 (2.7)[a]	30.3 (3.0)			
RT1-3	31.7 (4.6)	32.6 (4.2)[a]		.70 (.21-1.20)		
RT1	32.0 (4.5)	32.7 (3.8)	31.2 (4.3)[b]		-.79 (-1.42- -.17)	.19 (-.41-.78)
RT2	31.4 (5.5)	32.2 (4.6)	32.1 (4.6)		-.22 (-.81-.38)	.51 (-.10-1.10)
RT3	31.8 (4.0)	32.7 (4.1)	31.3 (3.9)[b]		-.66 (-1.27--.06)	.21 (-.37-.78)
Action planning						
CG	11.4 (2.2)	11.6 (1.6)	11.0 (2.7)			
RT1-3	10.9 (2.8)	12.5 (2.4)[a]		.52 (.03–1.00)		
RT1	11.6 (2.8)	12.2 (2.8)	12.5 (2.0)		.09 (-.52–.69)	.61 (-.01–1.21)
RT2	10.5 (3.0)	12.5 (2.5)	12.7 (2.1)[c]		.08 (-.52–.67)	1.17 (.52–1.78)
RT3	10.6 (2.9)	12.7 (2.7)	12.4 (1.8)[c]		-.10 (-.69–.49)	1.05 (.43–1.65)
Coping planning						
CG	10.8 (2.8)	10.5 (2.1)	10.3 (12.3)			
RT1-3	10.0 (2.8)	11.4 (2.5)[a]		.52 (.03–1.00)		
RT1	11.0 (2.7)	11.2 (2.8)	11.9 (1.9)		.06 (-.54–.66)	.43 (-.18–1.02)
RT2	10.3 (2.7)	11.6 (2.2)	11.7 (2.2)[c]		-.26 (-.85–.34)	.75 (.13–1.35)
RT3	8.9 (2.7)	11.2 (2.6)	11.1 (1.8)[c]		-.27 (-.86–.33)	.94 (.32–1.52)
PA: External						
CG	2.1 (1.0)	1.9 (1.2)	1.8 (0.7)			
RT1-3	2.4 (1.4)	2.4 (1.3)		.25 (-.23–.74)		
RT1	2.8 (1.8)	2.4 (1.7)	2.6 (1.6)		.33(-.28–.93)	.23 (-.37–.86)
RT2	2.0 (0.9)	2.2 (1.0)	2.2 (1.0)		-.03 (-.62–.57)	.55 (-.06–1.13)
RT3	2.4 (1.3)	2.6 (1.2)	2.2 (1.0)		-.34 (-.93–.26)	.05 (-.52–.63)
PA: Introjected						
CG	4.0 (1.2)	4.2 (1.3)	4.0 (1.0)			
RT1-3	2.1 (1.3)	4.3 (1.1)		-.29 (-.77–.20)		
RT1	4.5 (1.4)	4.1 (1.3)	4.0 (1.3)[c]		.18 (-.42–.78)	-.33 (-.92–.27)
RT2	3.8 (1.1)	3.8 (1.2)	4.1 (1.2)		.61 (-.01–1.20)	.56 (-.05–1.15)[d]

RT3	4.0 (1.4)	3.8 (1.4)	4.0 (1.0)		.26 (-.34–.84)	.13 (-.45–.70)
PA: Identified						
CG	6.1 (1.0)	5.9 (1.1)	5.9 (1.0)			
RT1-3	6.2 (0.8)	6.2 (0.9)		.51 (.02–1.00)		
RT1	6.2 (0.8)	6.3 (0.8)	6.1 (0.7)		-.21 (-.81–.40)	.29 (-.31–.88)
RT2	6.3 (0.7)	6.2 (1.0)	6.3 (0.7)		.22 (-.38–.80)	.51 (-.09–1.10)
RT3	6.0 (0.9)	6.1 (0.9)	6.1 (0.8)		.01 (-.58–.60)	.59 (.00–1.17)
PA: Intrinsic						
CG	5.6 (1.2)	5.7 (1.2)	5.6 (0.9)			
RT1-3	5.8 (1.1)	5.9 (1.1)		.20 (-.29–.68)		
RT1	5.8 (1.1)	5.7 (1.2)	5.7 (0.9)		-.18 (-.78–.42)	.20 (-.40–.79)
RT2	5.7 (1.0)	5.8 (1.2)	6.0 (0.9)		.52 (-.09–1.11)	.65 (.04–1.24)
RT3	5.8 (1.1)	5.8 (1.1)	6.0 (0.9)		.41 (-.20–1.00)	.67 (.07–1.25)
TR: External						
CG	3.3 (1.5)	3.1 (1.5)	2.9 (1.2)			
RT1-3	3.7 (1.8)	3.6 (1.6)		.08 (-.40–.56)		
RT1	4.0 (1.8)	3.5 (1.7)	3.6 (1.6)		.35 (-.27–.94)	.07 (-.52–.66)
RT2	3.7 (1.9)	3.4 (1.6)	3.6 (1.5)		.28 (-.31–.87)	.21 (-.38–.80)
RT3	3.4 (1.7)	3.5 (1.5)	3.2 (1.5)		-.23 (-.82–.37)	.09 (-.49–.66)
TR: Introjected						
CG	4.1 (0.8)	4.1 (1.1)	3.9 (0.8)[c]			
RT1-3	4.3 (1.1)	4.1 (1.2)[a]		-.22 (-.70–.27)		
RT1	4.5 (1.3)	4.2 (1.3)	4.1 (1.1)		.07 (-.53–.68)	.36 (-.25–.95)
RT2	4.3 (1.1)	3.8 (1.1)	4.1 (0.9)		.53 (-.08–1.12)	-.03 (-.61–.56)
RT3	4.3 (1.0)	4.3 (1.1)	4.0 (1.0)[c]		-.38 (-.97–.23)	-.07 (-.65–.50)
TR: Identified						
CG	5.9 (1.1)	5.7 (1.1)[a]	5.7 (1.1)			
RT1-3	6.1 (0.9)	6.1 (1.0)		.65 (.15–1.13)		
RT1	6.1 (0.8)	6.2 (0.9)	6.1 (0.8)		-.22 (-.82–.39)	.36 (-.25–.95)
RT2	6.2 (0.8)	6.0 (1.1)	6.2 (0.8)		.15 (-.45–.74)	.51 (-.10–1.10)
RT3	5.9 (1.1)	6.1 (0.9)	6.0 (1.0)		-.27 (-.86–.32)	.45 (-.14–1.03)
TR: Intrinsic						
CG	5.4 (1.4)	5.3 (1.3)	5.3 (1.1)			

RT1-3	5.5 (1.2)	5.8 (1.3)[a]		.64 (.14–1.13)		
RT1	5.7 (1.2)	5.8 (1.2)	5.4 (1.1)		-.51 (-1.11–.11)	.09 (-.50–.68)
RT2	5.6 (1.0)	5.7 (1.4)	5.9 (1.0)		.27 (-.33–.86)	.75 (.13–1.35)[e]
RT3	5.3 (1.3)	5.9 (1.1)	5.9 (1.2)[c]		-.03 (-.62–.57)	1.07 (.44–1.66)[f]

PA = motivational regulation related to physical activity, TR = motivational regulation related to training. Significant ($p<.05$) difference within group between [a]baseline and month-3, [b]month-3 and month-9, [c]baseline and month-9. [d]Effect size compared to RT1 0.84 (CI 0.25–1.42). [e]Effect size compared to RT1 0.57 (CI 0.00–1.15). [f]Effect size compared to RT1 0.84 (CI 0.31–1.37).

Table 4. The level of motivational and volitional characteristics post-intervention and changes during the intervention for non-continuers, once-a-week continuers and twice-a-week continuers.

	Non-continuers (n=42)	Once-a-week continuers (n=17)	Twice-a-week continuers (n=19)	
	n (%)	n (%)	n (%)	
Intervention group				5.05(4), 282[a]
RT1	16 (64%)	6 (24%)	3 (12%)	
RT2	13 (50%)	7 (27%)	6 (23%)	
RT3	13 (48%)	4 (15%)	10 (37%)	
	mean (SD)	mean (SD)	mean (SD)	F(df), p[b]
The level at post-intervention (9 months)				
Self-efficacy	31.0 (4.7)	32.0 (3.6)	32.1 (3.7)	.59(2), .556
Action planning	12.3 (1.9)	12.5 (2.0)	13.1 (2.1)	.98(2), .380
Coping planning	11.4 (2.3)	12.2 (1.1)	11.5 (1.9)	1.22(2), .301
PA: External	2.5 (1.3)	2.0 (1.1)	2.1 (1.2)	1.21(2), .305
PA: Introjected	4.0 (1.2)	4.0 (1.3)	4.1 (1.4)	.04(2), .959
PA: Identified	6.1 (0.8)	6.2 (0.6)	6.3 (0.8)	.16(2), .853
PA: Intrinsic	5.8 (1.0)	6.0 (0.9)	6.1 (0.9)	.78(2), .461
TR: External	3.4 (1.5)	3.3 (1.4)	3.5 (1.7)	.53(2), .590
TR: Introjected	4.1 (1.0)	3.9 (1.0)	4.0 (1.0)	.16(2), .849
TR: Identified	6.1 (0.9)	6.0 (0.8)	6.3 (1.0)	.16(2), .856

TR: Intrinsic	5.6 (1.2)	5.8 (0.9)	6.0 (1.2)	2.20(2), .118
Change during the intervention (from 0 to 9 months)				
Self-efficacy	-1.1 (3.3)	0.1 (3.2)	1.5 (3.4)	4.07(2), **.021**[c]
Action planning	1.6 (2.8)	1.7 (2.6)	1.7 (2.5)	.04(2), .961
Coping planning	1.5 (3.1)	1.9 (1.7)	1.3 (2.1)	.22(2), .803
PA: External	-0.1 (1.0)	-0.0 (1.0)	0.0 (0.5)	.08(2), .924
PA: Introjected	-0.1 (1.1)	-0.1 (1.1)	0.1 (1.0)	.71(2), .754
PA: Identified	0.0 (0.8)	-0.1 (0.6)	0.2 (0.7)	2.25(2), .494
PA: Intrinsic	0.1 (0.9)	-0.1 (0.9)	0.5 (0.6)	1.55(2), .112
TR: External	-0.4 (1.4)	-0.3 (1.2)	0.2 (1.0)	.78(2), 218
TR: Introjected	-0.3 (0.8)	-0.4 (0.8)	-0.1 (0.8)	.78(2), .464
TR: Identified	-0.0 (0.8)	-0.0 (0.9)	0.3 (0.6)	1.18(2), .313
TR: Intrinsic	0.1 (1.0)	0.2 (1.0)	0.9 (0.6)	6.94(24), **.002**[d]

Between-group differences analyzed by [a]Chi-square test or [b]one-way ANOVA. Bonferroni post-hoc tests:[c] difference between non-continuers vs. twice-a-week continuers, [d] difference between non-continuers vs. twice-a-week continuers and once-a-week continuers vs. twice-a-week continuers. PA = motivational regulation related to physical activity, TR = motivational regulation related to training.

Figure legends

Figure 1. Flowchart of the study.

Figure 2. Key findings: relative changes (± standard error estimation) in motivational characteristics between baseline and month-3 (Fig. A), between month-3 and month-9 (Fig. B) and between baseline and month-9 (Fig. C). TR= Training, PA=Physical Activity.

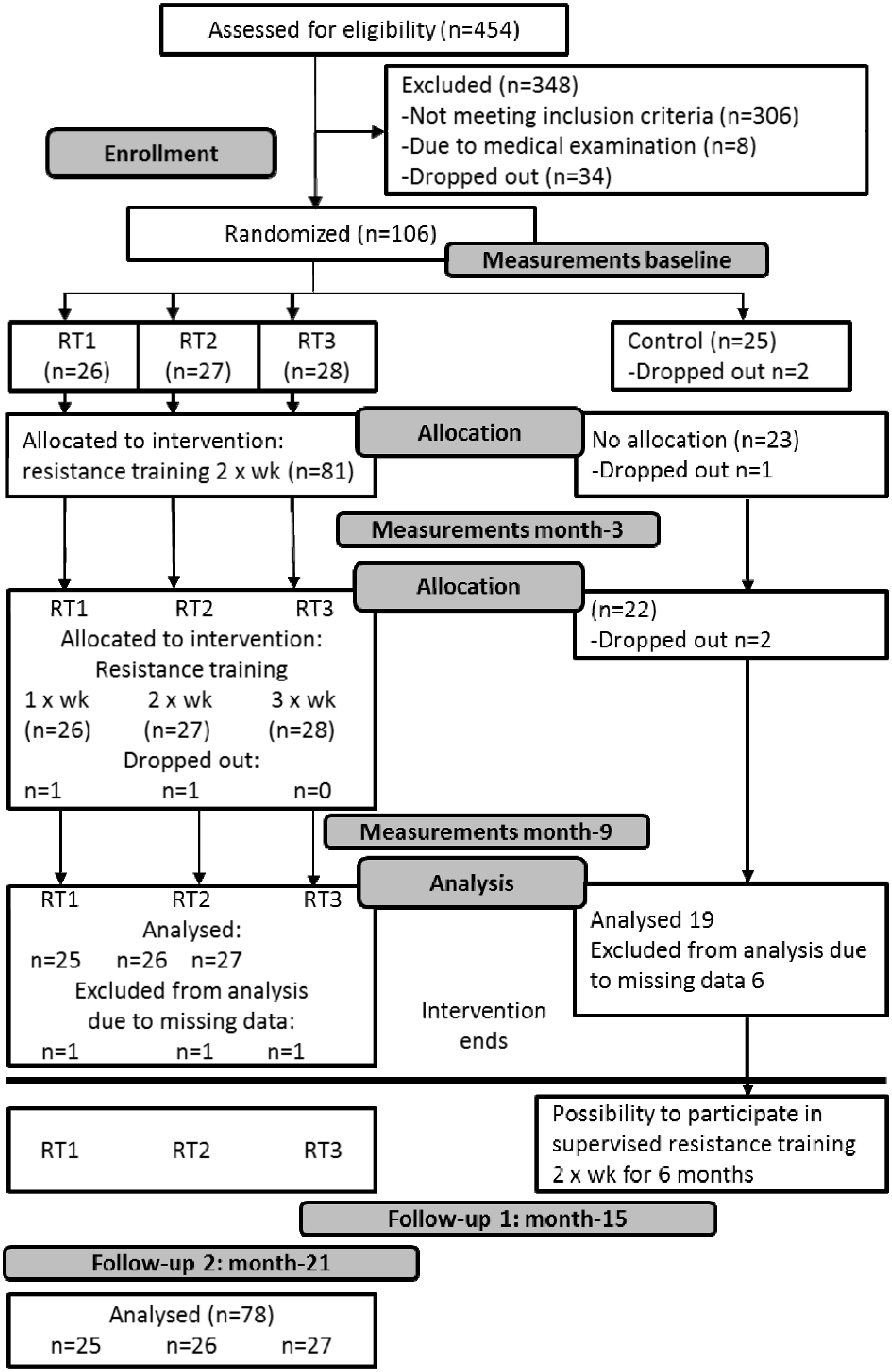
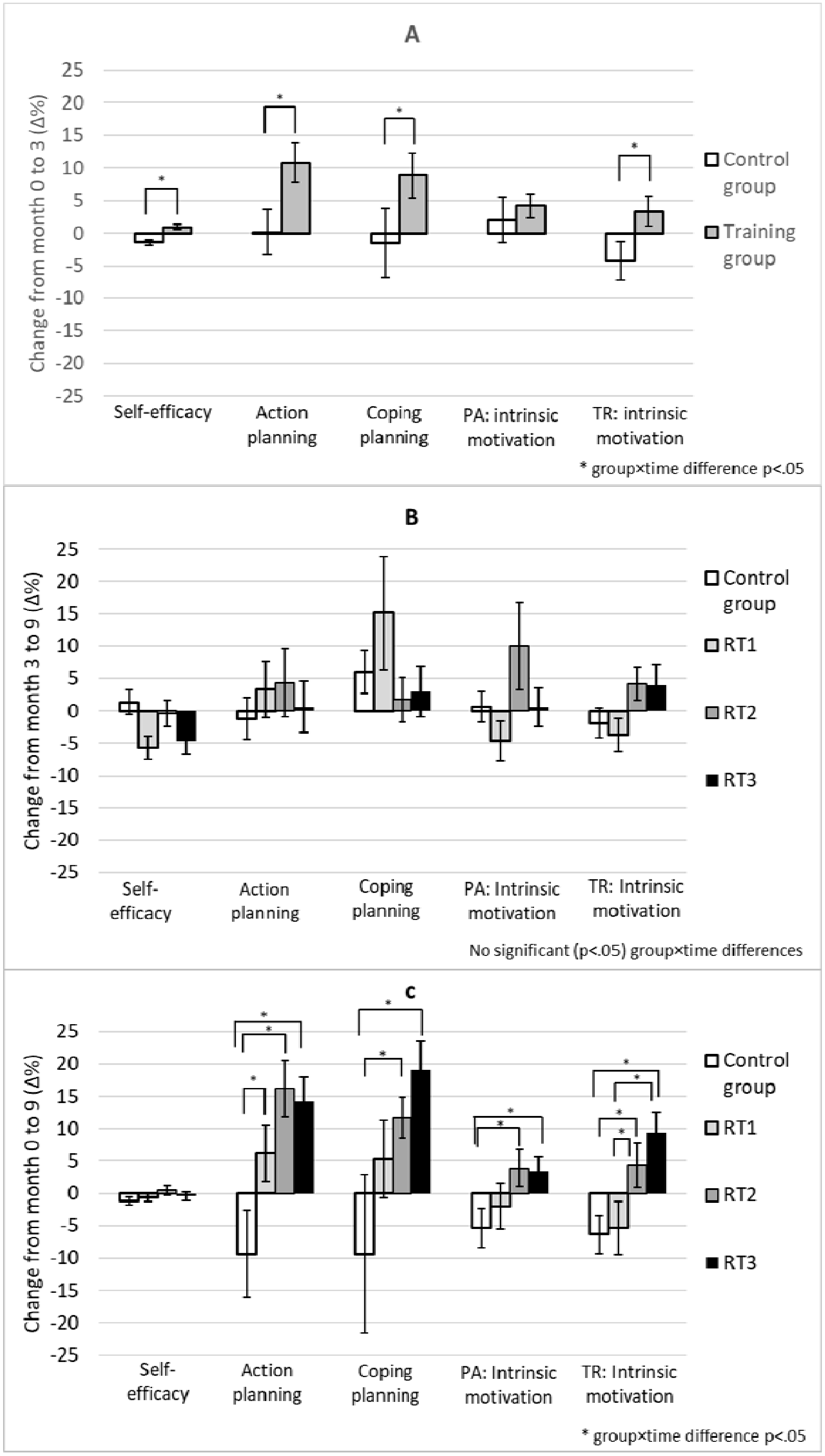

Assessed for eligibility (n=454)
Excluded (n=348)
-Not meeting inclusion criteria (n=306)
-Due to medical examination (n=8)
-Dropped out (n=34)
Enrollment
Randomized (n=106)
Measurements baseline
RT1 (n=26)
RT2 (n=27)
RT3 (n=28)
Control (n=25)
-Dropped out n=2
Allocated to intervention: resistance training 2 x wk (n=81)
Allocation
No allocation (n=23)
-Dropped out n=1
Measurements month-3
Allocation
RT1 RT2 RT3
Allocated to intervention:
Resistance training
1 x wk 2 x wk 3 x wk
(n=26) (n=27) (n=28)
Dropped out:
n=1 n=1 n=0
(n=22)
-Dropped out n=2
Measurements month-9
Analysis
RT1 RT2 RT3
Analysed:
n=25 n=26 n=27
Excluded from analysis due to missing data:
n=1 n=1 n=1
Analysed 19
Excluded from analysis due to missing data 6
Intervention ends
RT1 RT2 RT3
Possibility to participate in supervised resistance training 2 x wk for 6 months
Follow-up 1: month-15
Follow-up 2: month-21
Analysed (n=78)
n=25 n=26 n=27

Figure 1.


A
Change from month 0 to 3 (Δ%)
25
20
15
10
5
0
-5
-10
-15
-20
-25
Self-efficacy
Action planning
Coping planning
PA: intrinsic motivation
TR: intrinsic motivation
Control group
Training group
* group×time difference p<.05
B
Change from month 3 to 9 (Δ%)
Self-efficacy
Action planning
Coping planning
PA: Intrinsic motivation
TR: Intrinsic motivation
Control group
RT1
RT2
RT3
No significant (p<.05) group×time differences
C
Change from month 0 to 9 (Δ%)
Self-efficacy
Action planning
Coping planning
PA: Intrinsic motivation
TR: Intrinsic motivation
Control group
RT1
RT2
RT3
* group×time difference p<.05