Affective responses to supervised 10-week programs of resistance exercise in older adults

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Original article

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Abstract

Background: Resistance exercise has numerous, well-documented benefits on the health and functional performance of older adults. However, little information exists on the affective responses to resistance exercise in this population. As affective responses can predict continued exercise behavior, examining if and how they differ between resistance exercise intensities and frequencies in older adults may provide important data to improve resistance exercise prescription.

Methods: We monitored the affective responses of older adults when performing high-velocity, low-load (HVLL) or low-velocity, high-load (LVHL) resistance exercise once or twice weekly. A total of 40 moderately to highly active, but resistance-exercise naïve, older adults (60−79 years) completed 1 of 4 randomly assigned progressive resistance exercise conditions: HVLL once weekly (HVLL1: $n = 10$), HVLL twice weekly (HVLL2: $n = 10$), LVHL once weekly (LVHL1: $n = 10$), or LVHL twice weekly (LVHL2: $n = 10$). The Physical Activity Affect Scale, Felt Arousal Scale, Feeling Scale, rating of perceived exertion, Visual Analog Scale, and the Physical Activity Enjoyment Scale were used to assess enjoyment and affective responses.

Results: The results from Physical Activity Enjoyment Scale (out of 35) suggest that all exercise conditions were largely and similarly enjoyable to older adults (HVLL1: 30.9 ± 2.4; LVHL1: 31.9 ± 3.6; HVLL2: 30.9 ± 3.5; LVHL2: 30.2 ± 3.7) despite greater fatigue ($p = 0.033$; $\eta_p^2 = 0.22$) and perceived workload ($p = 0.042$; $\eta_p^2 = 0.20$) in LVHL (results from Visual Analog Scale).

Conclusion: Moderately to highly physically active older adults may tolerate higher intensities of resistance exercise performed once or twice weekly without experiencing a negative impact on enjoyment. However, the role that supervision and social interaction played in shaping the participants' responses is unclear.

Keywords: Aging; Enjoyment; Exercise affect; Health education; Older adults

1. Introduction

The age-related decrease in physical activity (PA) predisposes older adults to losses in muscle size and strength, which negatively impacts functional capacity, independence and quality of life.[1] PA Guidelines in the UK recommend that older adults complete ≥150 min of moderate aerobic activity per week (or 75 min of vigorous aerobic activity), accompanied by strengthening exercises on ≥2 days per week.[2] However, few older adults in the UK (15% of men and 10% of women) are achieving these recommended amounts of PA.[3] Notably, the current PA guidelines primarily reflect physiologically driven considerations instead of addressing the significant participation issues.[4] Therefore, it is important to determine whether, and to what extent, individuals enjoy exercise,[4] since enjoyment is a motivator for exercise[5] and is important for adherence to exercise interventions.[6] Previously, there has been investigation into the affective responses to aerobic exercise, but much less into resistance exercise,[7] especially in older adults, despite the well-documented benefits that resistance exercise offers this population.[8]

Commonly, 2 types of resistance exercise—high-velocity, low-load (HVLL) and low-velocity, high-load (LVHL) (types of power and strength training, respectively)—have garnered research interest. Despite a systematic review by Byrne et al.,[9] suggesting that power training seems to be more beneficial than strength training for gains in muscle power and/or

functional performance in older adults, Fisher et al.[10] suggested that slower velocity movements performed at greater effort, or to momentary failure, should be favored and that explosive movements should be avoided during resistance exercise in older adults. This claim was strongly refuted by Cadore et al.,[11] citing literature that supports the use of explosive muscle contractions in older adults for optimizing functional ability, reducing falls, stimulating muscle hypertrophy, and improving muscle strength and power. This finding suggests that the optimal exercise prescription from a physiological standpoint is still being debated and the psychological considerations for resistance exercise programming in older adults go largely uninvestigated.

The basic premise of hedonic theory is that human behavior is motivated by the pursuit of pleasure and the avoidance of displeasure.[12] The theory focuses on the affective responses to behaviors and how they influence decisions on whether or not a behavior is repeated.[13] The theory behind why affective responses to PA may alter future behaviors is principally based on operant conditioning, where behavior outcomes influence the continuation of that behavior through learned associations.[14] Exercise affect is a key component of the exercise experience and may be influenced through bodily sensations (e.g., pain or pleasure) or may follow from cognitive appraisal (e.g., feelings of failure or achievement).[15] Indeed, the measurement of the acute affective responses to exercise have been shown to predict future exercise behavior.[6] Therefore, understanding the affective responses to resistance exercise is important and could be used to influence resistance exercise program design in older adults.

As many older adults require supervision to realize the full benefits of resistance exercise,[16] costs to the individual can be substantial. Therefore, investigation into the minimal effective dose of resistance exercise for older adults is warranted.[9] Various studies have demonstrated that performing resistance exercise once weekly can elicit improvements in strength and physical function in older adults.[17,18] Recently Fisher et al.[10] proposed that as little as 10−30 min of resistance exercise twice weekly may be sufficient to obtain not only considerable physiological, but also psychological benefits, including a decrease in depressive symptoms, improved cognitive function, decreased fear of falling, improved self-esteem, and decreased anxiety. Furthermore, a lower frequency of resistance exercise may be preferable, given that Foley et al.[17] observed that 66% of 94 older adults preferred training once weekly compared with twice weekly (26%) or thrice weekly (1%). Given the potential importance of low-dose resistance exercise, investigation into the affective responses to lower doses (once weekly) and higher doses (twice weekly) of resistance exercise in older adults would be an important contribution to the extant literature.

Previous investigations into the acute affective responses to supervised HVLL and LVHL in older adults indicated that, despite LVHL being perceived as more exerting and fatiguing, both HVLL and LVHL were enjoyed similarly.[19] Although Richardson et al.[19] matched volume loads between conditions, intensity likely differed owing to the loading used, meaning that affective responses fluctuated in-task; however, postexercise affect for both HVLL and LVHL improved similarly. These patterns have been observed in other studies that have examined affective responses to resistance exercise.[20,21] The findings of Richardson et al.[19] formulated the basis for this study; the investigators suggested the need to investigate the differences between the 2 methods of resistance exercise from a more longitudinal perspective. Therefore, the present study aims to compare the affective responses of a group of older adults when carrying out a supervised 10-week training intervention of either HVLL or LVHL (exercise velocity and load) performed either once weekly or twice weekly (exercise frequency). We hypothesize the following: (1) there will likely be greater perceived exertion in the LVHL conditions, although based on the observations of Richardson et al.,[19] this factor may not necessarily negatively impact affective responses compared with HVLL and (2) given the active nature of the participants in the present study, both once weekly and twice weekly conditions will deliver similarly positive affective responses.

2. Materials and methods

2.1. Design

The present study used a randomized, multiarmed, parallel design. Blinding was not applied as it was apparent to the participants which exercise condition they had been allocated to. A control group was not deemed necessary as between-condition effects were the primary focus of the study.

2.2. Participants

An *a priori* power calculation using G*Power software (Version 3.1.9.2; Franz Faul, Universitat Kiel, Dusseldorf, Germany) for repeated measures analysis of variance (ANOVA), between−within interaction design (4 conditions by 3 time points (Weeks 1, 5, and 10)) revealed that detection of a medium effect size ($f = 0.20$), with $\alpha = 0.05$ and $1 - \beta = 0.80$, correlated dependent variables ($r = 0.70$), and a violation of the assumption of sphericity ($\varepsilon = 1$) required a minimum sample size of 40 participants. After receiving approval by the Coventry University Ethics Committee, community-dwelling men and women (aged 60−79 years; Table 1) were recruited by self-selection through advertisements for participation. Before randomization, each participant was required to meet the following inclusion/exclusion criteria: (1) absence of cognitive impairment, (2) absence of acute or terminal illness, myocardial infarction, symptomatic coronary artery disease, congestive heart failure, neuromuscular disease, or uncontrolled hypertension (>150/90 mmHg),[22] (3) no upper or lower extremity fracture in the previous 6 months, (4) no participation in strength or power training in the previous 6 months, and (5) aged ≥60 years with no upper age limit set for participation. After meeting these criteria, each older adult was assigned to 1 of 4 progressive resistance exercise conditions using minimization: (1) HVLL resistance exercise once weekly (HVLL1), (2) LVHL resistance exercise once weekly (LVHL1), (3) HVLL resistance exercise twice weekly

Table 1
Participant characteristics (total $n = 40$; $n = 10$, 5 males and 5 females in each group).

	HVLL1	LVHL1	HVLL2	LVHL2
Age (year)	66 ± 5	67 ± 4	67 ± 6	66 ± 6
Age range (year)	60−74	60−72	60−78	60−79
Height (cm)	168.7 ± 7.4	167.2 ± 11.1	173.3 ± 9.7	166.8 ± 8.9
Body mass (kg)	80.0 ± 16.9	76.3 ± 11.8	83.2 ± 13.5	73.0 ± 13.4
Body mass index (kg/m^2)	28 ± 5	28 ± 5	28 ± 5	26 ± 4
Physical activity (MET min/week)	2919 (1771−4345)	3264 (2064−4067)	3095 (2381−4487)	2355 (1074−4026)
Daily sitting (min)	330 (255−368)	195 (165−285)	240 (180−263)	360 (255−465)
Medications taken	2 ± 5	1 ± 1	1 ± 1	2 ± 2

Notes: Values are presented as mean ± SD except for age range, physical activity, and sitting, which are the range, median, and interquartile ranges, respectively.
Abbreviations: HVLL1 = high-velocity, low-load once weekly; HVLL2 = high-velocity, low-load twice weekly; LVHL1 = low velocity, high-load once weekly; LVHL2 = low-velocity, high-load twice weekly; MET = metabolic equivalent.

(HVLL2), or (4) LVHL resistance exercise twice weekly (LVHL2). All participants were made aware of the exercise conditions and associated risks before providing written informed consent. The Consolidated Standards of Reporting Trials (CONSORT) diagram (Supplementary Fig. 1) displays that 40 participants completed all assessments and were included in the analysis.

2.3. Procedures

Before familiarization and estimation of 1 repetition maximum (1-RM), participants were asked to refrain from any other fatiguing exercise or PA for 24 h. First, anthropometric data was recorded (Seca Instruments, Hamburg, Germany), and participants completed the International Physical Activity Questionnaire short form (IPAQ)[23] to assess habitual PA levels (Table 1). The IPAQ is a useful tool for assessing the PA of older adults[24] and was scored (and data were reported) in accordance with instructions on the IPAQ website (www.ipaq. ki.se). Furthermore, as participants who exercise more frequently report a more positive exercise experience,[25] these self-reported PA levels (metabolic equivalent min/week, estimated from the IPAQ), were used as a covariate for all measures of exercise affect.

Before each exercise session, participants performed a warm-up comprising 5 min of cycling at a self-selected pace,

followed by 5 dynamic stretches that targeted the main muscle groups. Then, each individual participant's ideal anthropometric setup for each piece of Cybex equipment (Cybex, Medway, MA, USA) was recorded for each of the 8 exercises: (1) leg press, (2) seated row, (3) chest press, (4) leg extension, (5) leg curl, (6) calf raise, (7) triceps extension, and (8) bicep curl. The correct techniques for all exercises as described by Cybex were demonstrated to participants, who practiced them until movements were being performed correctly and safely. Finally, participants completed a protocol described in Richardson et al.[19] to predict 1-RM for all 8 exercises using a prediction equation,[26] which has been shown to produce valid estimations of 1-RM for multiple machine-based exercises in older adults.[27] Table 2 displays the predicted 1-RMs achieved by all participants both at baseline and after the 10-week intervention period.

2.4. Measures of exercise affect

As is consistent with hedonic theory,[28] the measures selected assessed the pleasantness and enjoyment of the resistance exercise conditions using both the dimensional model and distinct state approaches. It has been suggested that in-task affect is an important consideration in the intensity-affect-enjoyment relationship during resistance exercise.[7] However, previous research has shown that in-task responses

Table 2
Predicted 1-RM data (Brzycki[26]) at baseline and after the intervention (mean ± SD).

	Leg press (kg)	Seated row (kg)	Chest press (kg)	Leg extension (kg)	Leg curl (kg)	Calf raise (kg)	Triceps extension (kg)	Bicep curl (kg)
HVLL1 baseline	103 ± 23	53 ± 14	35 ± 14	41 ± 8	40 ± 12	116 ± 21	25 ± 10	20 ± 10
HVLL1 post	117 ± 29	57 ± 13*	39 ± 16	45 ± 9	45 ± 6	136 ± 29*	29 ± 8*	23 ± 9
LVHL1 baseline	104 ± 29	51 ± 15	33 ± 21	42 ± 14	37 ± 12	97 ± 31	23 ± 12	20 ± 10
LVHL1 post	125 ± 32*	58 ± 17*	38 ± 20*	52 ± 15*	45 ± 17*	126 ± 32*	28 ± 12*	24 ± 10*
HVLL2 baseline	135 ± 39	59 ± 21	44 ± 21	55 ± 21	48 ± 17	139 ± 31	30 ± 16	26 ± 12
HVLL2 post	150 ± 44	65 ± 24*	50 ± 20*	60 ± 19*	53 ± 20*	148 ± 32	35 ± 15*	29 ± 11*
LVHL2 baseline	114 ± 28	51 ± 15	38 ± 19	42 ± 10	41 ± 11	117 ± 26	25 ± 10	20 ± 10
LVHL2 post	143 ± 41*	65 ± 18*	48 ± 23*	60 ± 15*	53 ± 14*	158 ± 26*	33 ± 12*	29 ± 13*

* $p < 0.05$, compared with baseline.
Abbreviations: 1-RM = 1 repetition maximum; HVLL1 = high-velocity, low-load once weekly; HVLL2 = high-velocity, low-load twice weekly; LVHL1 = low-velocity, high-load once weekly; LVHL2 = low-velocity, high-load twice weekly.

are typically stronger and in the same direction as post-task affect.[29] Additionally, Richardson et al.[19] observed similarly positive affective responses to the same HVLL and LVHL conditions when affect was measured immediately after each set of each exercise in older adults. Therefore, in-task affect was not measured in the present study. Finally, when completing all applicable measures, participants were advised to base their responses on the exercise they performed and not the overall experience (e.g., socializing or interaction with others etc.).

2.5. Physical Activity Affect Scale (PAAS)

Participants completed a PAAS questionnaire[30] before and immediately after sessions in Weeks 1, 5, and 10. The PAAS questionnaire measures acute exercise-induced affect, incorporating a multidimensional perspective assessing valence and arousal.[31] The questionnaire displays a total of 12 statements that might describe one's feelings at a given moment. Participants indicated their feelings according to the following levels: *do not feel* (0), *feel slightly* (1), *feel moderately* (2), *feel strongly* (3), or *feel very strongly* (4). The 12 statements are grouped into 4 subscales: positive affect, negative affect, fatigue, and tranquility.

2.6. Felt Arousal Scale (FAS) and Feeling Scale (FS)

The FAS[32] and single-item FS[33] were used to measure arousal and affective valence, respectively, before exercise and immediately after sessions in Weeks 1, 5, and 10. Participants rated their arousal level from 1 (*very low*) to 6 (*very high*), using the 6-point FAS. It was explained to participants that high arousal might be characterized by feelings of excitement, anxiety, or anger and that low arousal might be explained by feelings of relaxation, boredom, or calmness. The FS uses an 11-point bipolar scale, which ranges from *very bad* (−5) to *very good* (+5). The PAAS, FS, and FAS were all used to assess affective valence and arousal because of the accepted strengths and weaknesses of single-item and multi-item scales.[34]

2.7. Rating of perceived exertion (RPE)

RPE[35] was recorded using a scale ranging from 6 to 20 (6 = *no exertion at all*, 20 = *maximal exertion*) immediately after sessions in Weeks 1, 5 and 10. As well as monitoring perceived exertion, RPE was used to progress exercise intensity. Similar to the method used by Levinger et al.,[36] when a participant rated the session 10 of 20 on the Borg scale (too light/easy), any exercises that the participant rated as too easy in that session were increased in resistance by 5%−10%. To avoid the possibility of deliberate manipulation of RPE ratings, participants were not informed that rating a session as 10 out of 20 would result in increasing resistance. Only 1 participant in the LVHL2 condition rated the final session as an RPE of 10. In the HVLL1 condition, 4 participants rated the sessions as an RPE of 10 by Week 8. For the HVLL2 condition, 2 participants rated sessions as an RPE of 10 by Week 6. No

participants in the LVHL1 condition rated sessions as an RPE of ≤10.

2.8. Visual Analog Scales (VAS)

After sessions in Weeks 1, 5, and 10, participants completed 4 VAS.[37] All VAS spanned a single 100-mm horizontal line with a headline statement at the top. To the extreme left of the line was a statement that indicated no agreement with the headline statement, for example, no enjoyment, and to the extreme right was a statement that indicated strong agreement, for example, very enjoyable. Participants indicated their feelings immediately at the end of each session with a single vertical line. The 4 VAS headline statements used were: (1) How enjoyable was the exercise you just did? (2) How fatiguing was the exercise you just did? (3) What was your perception of the workload? and (4) What was your perceived effectiveness of the workload?

2.9. Physical Activity Enjoyment Scale (PACES)

Finally, participants completed a modified PACES[38] after sessions in Weeks 1, 5, and 10. The PACES displays 2 contrasting statements about exercise, such as, "I like it" and "I dislike it". Between the 2 statements, participants rated their agreement with each statement on a 7-point Likert scale. The 2 inversely scored PACES questions were corrected before being analyzed as a total score (out of 35, with a possible range of 5 to 35). The PACES has been shown to be a reliable instrument for assessing the enjoyment of PA in older adults.[39] In the present sample, using pooled data for all conditions, the PACES exhibited acceptable internal consistency (Cronbach's $\alpha = 0.75$).

2.10. Exercise interventions

During each supervised session, all exercise conditions performed the 8 exercises detailed in Table 2. Both the HVLL1 and HVLL2 conditions performed 3×14 repetitions at 40% 1-RM on each exercise. The concentric phase was performed as fast as possible without causing unloading of the weight stack, followed by a 3-s eccentric phase. Both the LVHL1 and LVHL2 conditions performed 3×7 repetitions at 80% predicted 1-RM. The concentric phase was performed over 2 s with a 3-s eccentric phase. All exercise conditions had 90 s recovery between sets, and a 3-min recovery between exercises. Sessions were completed at the same time of day on the same days of the week where possible to control for possible diurnal variation. The HVLL1 and LVHL1 conditions performed 1 session weekly for 10 weeks (10 sessions), and the HVLL2 and LVHL2 conditions performed 2 sessions weekly for 10 weeks (20 sessions). This study design meant that participants in the twice weekly conditions performed double the weekly training volume compared with participants in the once weekly conditions. It is the opinion of the authors that matching volumes between once weekly and twice weekly is not time efficient, that is, one-half of the volume on 2 days weekly or may overload participants, or double the training

volume on just 1 day weekly. Where any sessions were missed, the intervention period was extended so that all sessions could be completed. Therefore, the mean number of weeks to complete all sessions were: HVLL1: 10.4 ± 0.7, LVHL1: 10.8 ± 0.9, HVLL2: 10.6 ± 0.7, and LVHL2: 10.8 ± 1.2. Supplementary Fig. 2 displays the timeline of sessions and displays when all measurements were taken during each session.

2.11. Supervision

A single male researcher supervised all baseline, postintervention, and weekly exercise sessions to (1) ensure participant attendance, (2) provide feedback, technical instructions, and motivation, (3) provide social and mental support, and (4) provide a supportive attitude.[40] To try to standardize these elements among participants and sessions, the researcher (1) provided encouragement and motivation at times when a participant was visibly struggling with an exercise, (2) provided praise on completion of each set, and (3) delivered any necessary constructive criticism to improve technique at the end of each exercise. The baseline and post-testing sessions were closely supervised 1:1 (researchers:participants). Each subsequent session was supervised 1:2 throughout the duration of the intervention period. Before and after each session, participants completed all scales separately before being allowed to socialize with each other and the researcher. During each session, participants were permitted to socialize with each other and the researcher during the warm-up, but once the session began they had no interaction with each other as they performed different exercises.

2.12. Statistical analysis

All data were analyzed using IBM SPSS Statistics (Version 24.0; IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as mean ± SD, with 95% confidence intervals (CIs). Recognizing that they are highly correlated measures, after meeting the relevant assumptions, the FS, FAS, and the 4 PAAS subscales were analyzed using multivariate ANOVA with repeated measures before and after sessions in Weeks 1, 5, and 10. Factorial ANOVA with repeated measures examined the effect of the independent variable: exercise condition on the dependent variables—namely, PAAS, PACES, RPE, VAS, FS, and FAS. When Mauchly's test of sphericity was significant and the Greenhouse−Geisser level of violation was >0.75, degrees of freedom were corrected using Huynh−Feldt adjustment; and when violation was <0.75, the Greenhouse−Geisser correction was used. Significant interactions and main effects were investigated with Bonferroni-corrected pairwise comparisons. Significance was determined by a p value of <0.05 and reported as exact values unless below $p = 0.001$. The effect size was used to quantify the meaningfulness of any differences and was calculated using η_p^2 and defined as trivial (<0.10), small (0.10−0.29), moderate (0.30−0.49), or large (≥0.50).[41] One-way ANOVA was used to confirm that no significant differences existed in activity levels between conditions, and paired sample t tests were used to show where

differences in strength changes lay (Table 2). Analysis of covariance was used to examine the effects of the covariate; habitual PA (metabolic equivalent min/week) on the dependent variables. However, there were no significant effects of metabolic equivalent min/week on any of the dependent variables. Ancillary ANOVA analyses were performed to analyze the effects of movement velocity only (HVLL ($n = 20$) vs. LVHL ($n = 20$)) or frequency of exercise only (once weekly ($n = 20$) vs. twice weekly ($n = 20$)) and are only reported where significant differences were observed.

3. Results

3.1. Multivariate ANOVA

The multivariate ANOVA performed on the FS, FAS, and the 4 PAAS subscales between exercise conditions indicated a nonsignificant effect (Pillai's V = 0.33, $F(15, 180) = 0.710$, $p = 0.773$, $\eta_p^2 = 0.06$). This suggests that all 4 exercise conditions produced similar affective responses. However, there was a significant interaction between FS, FAS, and the 4 PAAS × Weeks × Pre/post (Pillai's V = 0.61, $F(6, 202) = 3.445$, $p = 0.004$, $\eta_p^2 = 0.09$), which was further investigated with factorial ANOVA.

3.2. PAAS subscale

3.2.1. PAAS positive affect
There were increases in positive exercise affect from before to after the sessions ($F(1, 9) = 36.179$, $p < 0.001$, $\eta_p^2 = 0.80$) but no significant differences between exercise conditions ($F(3, 27) = 0.746$, $p = 0.534$, $\eta_p^2 = 0.08$).

3.2.2. PAAS negative affect
There were no significant differences in negative exercise affect between exercise conditions ($F(3, 27) = 1.974$, $p = 0.142$, $\eta_p^2 = 0.18$) and no significant differences in negative affect from before to after the sessions ($F(1, 9) = 4.853$, $p = 0.055$, $\eta_p^2 = 0.35$). However, when only velocity of exercise was analyzed, there was a significant exercise Velocity × Before and after session interaction ($F(1, 19) = 9.314$, $p = 0.007$, $\eta_p^2 = 0.33$; Fig. 1A). Pairwise comparisons revealed that negative exercise affect decreased significantly from before to after the session in Week 1 (95%CI: −0.4 to 0.0, $p = 0.042$) and Week 5 (95%CI: −0.3 to 0.0, $p = 0.029$) in HVLL. When only frequency was analyzed, there was a significant Frequency × Week interaction ($F(2, 38) = 4.523$, $p = 0.017$, $\eta_p^2 = 0.19$). Pairwise comparisons revealed that in Week 1, before exercise negative affect for twice-weekly participants was significantly greater (95%CI: 0.1−0.4, $p = 0.006$) than for once-weekly participants (Fig. 1B).

3.2.3. PAAS fatigue
There were significant increases in rating of fatigue before versus and after the session ($F(1, 9) = 26.320$, $p = 0.001$, $\eta_p^2 = 0.75$), with no differences between exercise conditions ($F(3, 27) = 0.396$, $p = 0.757$, $\eta_p^2 = 0.04$).
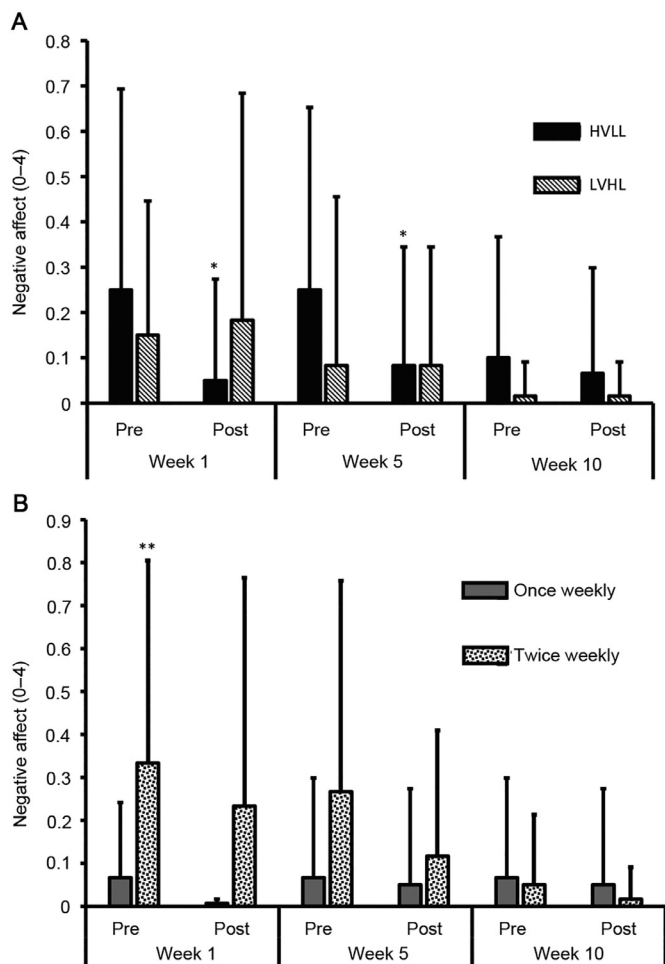
Fig. 1. The PAAS negative exercise affect (mean ± SD) when only velocity (A) and frequency (B) of exercise was analyzed. * $p < 0.05$, compared with before HVLL, ** $p < 0.01$, compared with the before Week 1, once weekly session. HVLL = high-velocity, low-load; LVHL = low-velocity, high-load; PAAS = Physical Activity Affect Scale.

3.2.4. PAAS tranquility

There were no significant differences in tranquility between exercise conditions ($F(3, 27) = 1.496$, $p = 0.238$, $\eta^2_p = 0.14$) and no significant changes in tranquility before $vs.$ after the session ($F(1, 9) = 4.300$, $p = 0.068$, $\eta^2_p = 0.32$).

3.3. FAS

There were significant increases in the FAS rating from before to after the session ($F(1, 9) = 36.506$, $p < 0.001$, $\eta^2_p = 0.80$), but no differences between exercise conditions ($F(3, 27) = 0.396$, $p = 0.757$, $\eta^2_p = 0.04$). When only frequency of exercise was analyzed, there was a significant interaction between Frequency × Week × Before to after the session ($F(2, 38) = 4.669$, $p = 0.015$, $\eta^2_p = 0.20$). Pairwise comparisons revealed that there were significant increases in FAS from before to after the session for once weekly after Week 1 (95%CI: 0.1–1.4, $p = 0.028$) and Week 5 (95%CI: 0.3–1.1, $p = 0.002$) and twice weekly saw significant increases in FAS after Week 1 (95%CI: 0.6–2.0, $p = 0.001$), Week 5 (95%CI: 0.1–0.7, $p = 0.008$), and Week 10 (95%CI: 0.1–0.7, $p = 0.017$) (Fig. 2).
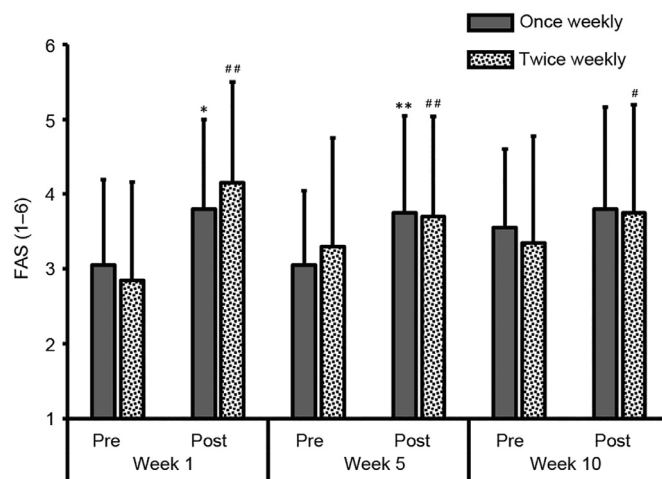

Fig. 2. FAS (mean ± SD) for all participants when only frequency of exercise was analyzed. * $p < 0.05$, ** $p < 0.01$, compared with before exercise in once weekly sessions; # $p < 0.05$, ## $p < 0.01$, compared with before exercise in twice weekly sessions. FAS = Felt Arousal Scale.

3.4. FS

There were significant increases in the FS rating from before to after the session ($F(1, 9) = 35.485$, $p < 0.001$, $\eta^2_p = 0.80$) but no significant differences between exercise conditions ($F(3, 27) = 0.467$, $p = 0.708$, $\eta^2_p = 0.05$).

3.5. RPE

There were significant decreases in RPE over the intervention period ($F(2, 18) = 17.189$, $p < 0.001$, $\eta^2_p = 0.66$) that were not significantly different between exercise conditions ($F(3, 27) = 1.188$, $p = 0.333$, $\eta^2_p = 0.12$). Pairwise comparisons revealed a significant decrease in RPE from Week 1 to Week 5 (95%CI: −2.0 to −0.2, $p = 0.022$) but a nonsignificant decrease between Week 5 and Week 10 (95%CI: −0.9 to 0.0, $p = 0.056$).

3.6. VAS

3.6.1. VAS Item 1: how enjoyable was the exercise you just did?
There were no significant differences in enjoyment between exercise conditions ($F(3, 27) = 1.347$, $p = 0.280$, $\eta^2_p = 0.13$).

3.6.2. VAS Item 2: how fatiguing was the exercise you just did?
There were no significant differences in fatigue between all exercise conditions ($F(3, 27) = 2.733$, $p = 0.063$, $\eta^2_p = 0.23$). When only velocity of exercise was analyzed, LVHL was significantly more fatiguing than HVLL ($F(1, 19) = 5.258$, $p = 0.033$, $\eta^2_p = 0.22$). Pairwise comparisons revealed that LVHL was significantly more fatiguing after Week 1 (95%CI: 5.0–30.0, $p = 0.009$) and Week 5 (95%CI: 2.2–35.0, $p = 0.028$) (Fig. 3).

3.6.3. VAS Item 3: what was your perception of the workload?
There was a significant Exercise condition × Week interaction ($F(6, 54) = 2.978$, $p = 0.014$, $\eta^2_p = 0.25$), although pairwise
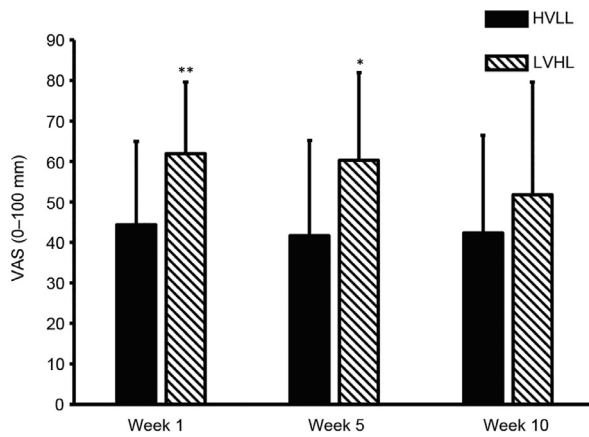
Fig. 3. VAS Item 2 (mean ± SD) when only velocity of exercise was analyzed. * $p < 0.05$, ** $p < 0.01$, compared with HVLL. HVLL = high-velocity, low-load; LVHL = low-velocity, high-load; VAS = Visual Analog Scale.

comparisons revealed that only LVHL2 Week 5 had a significantly greater perception of workload than LVHL2 Week 10 (95%CI: 4.4−26.4, $p = 0.008$) (Fig. 4A). When only velocity of exercise as analyzed, LVHL exercise was perceived as having a significantly greater workload than HVLL ($F(1, 19) = 4.766$, $p = 0.042$, $\eta_p^2 = 0.20$). Pairwise comparisons revealed that LVHL had a greater perceived workload in Week 1 only (95%CI: 4.7−27.4, $p = 0.008$) (Fig. 4B).

3.6.4. VAS Item 4: what was your perceived effectiveness of the workload?

There were no significant differences in VAS perceived effectiveness between all exercise conditions ($F(3, 27) = 0.959$, $p = 0.426$, $\eta_p^2 = 0.10$).

3.7. PACES total score

There were no significant differences in PACES scores between all exercise conditions ($F(3, 27) = 0.571$, $p = 0.639$, $\eta_p^2 = 0.06$). Table 3 displays PACES total score (out of 35).

4. Discussion

The present study sought to investigate the affective responses to performing HVLL and LVHL once weekly or twice weekly in older adults. This study is the first that has monitored the affective responses to 10-week interventions of resistance exercise differing in frequency, volume, and load in older adults. The observations from the present study are in agreement with a number of other studies that have demonstrated positive affective responses to resistance exercise.[7,21,42,43] Our findings seem to replicate the observations of Richardson et al.[19] in that, during both studies, LVHL elicited greater perceived workload and fatigue than HVLL, without having a detrimental impact on enjoyment. We also observed that affective responses were not different between those who performed resistance exercises once weekly or twice weekly. Although older adults have previously indicated a preference for a lower frequency of resistance exercise,[17] performing

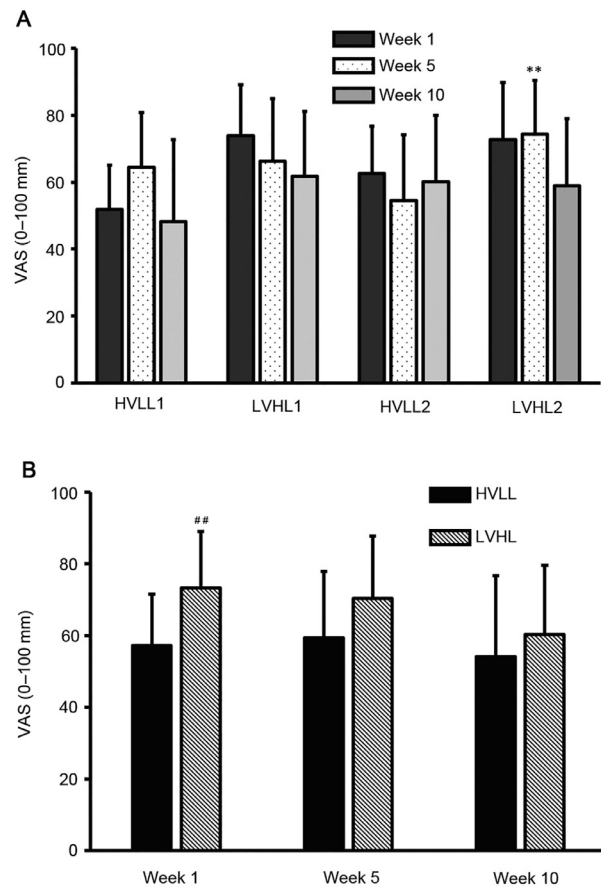
Fig. 4. VAS Item 3. Perception of workload between all 4 exercise conditions (A) and when only velocity of exercise was analyzed (B). ** $p < 0.01$, compared with LVHL2 Week 10, ## $p < 0.01$, compared with Week 1 HVLL. HVLL = high-velocity, low-load; LVHL = low-velocity, high-load; VAS = Visual Analog Scale.

double the weekly volume in the twice weekly conditions did not negatively impact enjoyment. Given that participants in the present study had moderate to high levels of habitual PA, we propose that they were more likely to report a positive exercise experience,[25] regardless of the exercise condition they were randomized to. Therefore, based on these observations, our findings support our hypotheses.

The PAAS for positive affect increased from before to after the exercise sessions across all exercise conditions, whereas negative exercise affect significantly decreased from before to after the session in the HVLL conditions for Week 1 and

Table 3
Physical Activity Enjoyment Scale (PACES) total score (out of 35) (mean ± SD).

	Week 1	Week 5	Week 10
HVLL1	30.7 ± 2.5	30.4 ± 2.5	31.6 ± 2.3
LVHL1	31.3 ± 3.7	32.0 ± 3.8	32.4 ± 3.6
HVLL2	30.2 ± 2.6	31.1 ± 4.1	31.4 ± 3.8
LVHL2	29.7 ± 3.6	30.1 ± 3.5	30.8 ± 4.2

Abbreviations: HVLL1 = high-velocity, low-load once weekly; HVLL2 = high-velocity, low-load twice weekly; LVHL1 = low-velocity, high-load once weekly; LVHL2 = low-velocity, high-load twice weekly; PACES = Physical Activity Enjoyment Scale.

Week 5. However, by Week 10, ratings were similar for both HVLL and LVHL. All exercise conditions saw large increases in FAS and FS from before to after exercise, which is similar to previous findings.[19] Results from the PACES and VAS revealed that all exercise conditions were found to be highly enjoyable despite the VAS for fatigue revealing that when data were analyzed by exercise velocity, the LVHL conditions were perceived as being significantly more fatiguing for Week 1 and Week 5, but not Week 10. Similarly, when VAS perception of workload was analyzed between exercise velocities, LVHL conditions were perceived as having significantly greater workload after Week 1, but not after Week 5 or Week 10. This finding suggests that, although older adults may have initially perceived LVHL as more difficult and more fatiguing, as they progressed through the program perceptions of HVLL and LVHL became more similar. This finding may be explained by the fact that 30% of participants in the HVLL conditions rated sessions as ≤10 on the RPE scale, meaning volume load was increased, whereas none of the participants in the LVHL conditions progressed through RPE ratings. Therefore, the volume load increases in HVLL conditions may be a reason why perception of fatigue became more similar by Week 10. Over a longer period of time, the ability for participants in the HVLL conditions to progress workloads (increase the total load lifted) at a quicker rate than participants in the LVHL conditions may provide them with a greater stimulus for physiological adaptations and gains in muscular strength and power. However, it is important to note that, even though volume loads were matched between HVLL and LVHL, the LVHL conditions, possibly owing to greater intensity, produced greater magnitudes of improvements in more estimations of 1-RM than HVLL at both frequencies of training despite not progressing load.

Richardson et al.[19] observed greater perception of fatigue with no negative impact on enjoyment or affective valence during LVHL compared with HVLL exercise in older adults, which are consistent with the findings of the present study. As the intensity of exercise in the LVHL conditions was greater than in HVLL, it may be reasonable to assume, based on hedonic theory, that this would have a negative impact on affective responses. The theory of optimal stimulation[44] suggests that, when individuals consider an activity threatening or beyond their capabilities (e.g., undertaking high-intensity resistance exercise, as in the LVHL conditions), it will result in negative affect, anxiety, or both. However, it is possible that, given the active nature of the participants in the present study, the greater intensity of LVHL was not enough to negatively impact affective responses or enjoyment. Therefore, we speculate that similarly high ratings of enjoyment have been observed regardless of exercise intensity or frequency because of the high habitual PA levels of the participating older adults.

The effect that supervision had on the reported affective responses during the present study is unclear. There is evidence that supervision has a positive influence on various physiological and performance outcomes during exercise programmes,[16,40] but there is very little investigation into how the role of the supervisor impacts exercise enjoyment and subsequent program adherence. Previously, it has been suggested that supervised exercise programs provide greater motivation for exercise[45] while improving psychosocial factors and quality of life through improvements in strength and functional performance.[40] However, the role that supervisors play in influencing affective responses to resistance exercise in older adults remains uninvestigated.

This study is not without limitations. As the same researcher conducted both baseline and postintervention assessment sessions, as well as all the sessions in the 10-week program, the researcher was not blinded to condition assignment. To counteract this potential bias, identical assessment procedures and motivation were provided to all participants.[46] It is possible that the high PACES scores were not a true indication that the exercise was enjoyed to a great extent in all conditions. Despite clear instructions to respond to all measures based on the exercise performed, it is unclear if socialization between participants and/or the researcher was really the driving force behind the high enjoyment found across all conditions. Future research examining if or how supervision can influence the enjoyment of resistance exercise in older adults would therefore be welcome. In addition, although the older adults who volunteered for the present study were resistance exercise naïve, they were moderately to highly active, meaning that caution should be applied when generalizing these findings to more sedentary older adults. Despite basing our decision to not assess intask effective responses on previous research,[19] we accept that it is possible that a relief effect was present and that the affective rebound after exercise may have distorted any differences between exercise conditions. Finally, it may have been useful to assess psychological states after a period of recovery as psychological responses to exercise may have been obscured by the physiological responses to exercise.

5. Conclusion

In the present study, both supervised HVLL and LVHL, whether performed once weekly or twice weekly, produced similar affective responses in a group of physically active older adults. The LVHL conditions were perceived to have a greater workload and to be more fatiguing, but this did not negatively impact enjoyment. This finding suggests that moderately to highly active older adults may report similarly positive affective responses when performing higher or lower intensity resistance exercise. As higher intensity resistance exercise has been suggested to be important for optimizing strength and functional performance gains in older adults,[10] exercise professionals may maximize the physiological benefits by using greater exercise intensities without compromising enjoyment and adherence. However, as participants in the present study were moderately to highly active, caution should be applied when generalizing these findings to more sedentary older adults. Future research should aim to better understand the role that supervision, social interaction, and habitual PA have on affective responses to resistance exercise programs for older adults.

Acknowledgments

Authors' contributions

DLR was involved in the inception of the study design, data collection, interpreting the data, and drafting the manuscript; MJD and NDC were involved in the inception of the study design, interpreting the data, and proof reading the manuscript; AJ and PMJ were involved in interpreting the data and proof-reading the manuscript. All authors have read and approved the final version of the manuscript, and have agreed with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Supplementary materials

Supplementary materials associated with this article can be found in the online version at doi:10.1016/j.jshs.2019.01.006.

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