Delivering web-based resistance training group sessions using rating of perceived effort: a randomized controlled trial

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Abstract

Background: Few individuals participate in resistance training (RT) despite its numerous health benefits. This study aimed to overcome known barriers to RT participation by developing and comparing two live, web-based, personalized RT prescription approaches, using a 0-10 rating of perceived effort (RPE) scale.

Methods: Fifty-seven healthy and untrained participants (60% females; age range: 18-45), were randomly assigned to one of two groups that received two weekly sessions of group RT sessions using resistance bands, for a period of eight weeks. In the fixed-repetition RPE group, participants selected the resistance and performed ten repetitions per set of each exercise aiming to reach a RPE of seven by the 10th repetition. In the open-repetition RPE group, participants selected their preferred resistance, and then completed repetitions until reaching a RPE of seven. We measured and compared adherence rates, body composition, a range of physical performance tests and questionnaires.

Results: We observed non-significant and trivial differences between groups in all outcomes ($p > .05$). We thus examined the pre-post change scores of the two groups combined. Adherence rates decreased from ~90% to ~50% from the first to the last session, respectively ($p \leq .001$). On average, participants increased their fat-free mass by 0.3 kg (95%CI: 0.01, 0.59), and improved their performance in the isometric mid-thigh pull by 5.5 kg (0.76, 10.39), isometric knee-extension by 2.2 kg (0.8, 3.7), and push-up test by 6.3 repetitions (4.5, 8.2). No statistical differences were observed in bodyweight (-0.72, 0.29 kg), isometric grip force (-0.57, 0.99 kg), and countermovement jump (-0.17, 1.09 cm). Participants reported high satisfaction rates in all components of the program (median range of 44 to 100 on a -100 to 100 scale).

Conclusions: While trivial differences were identified between groups, both approaches led to reasonable adherence rates, improvements in body composition and performance tests, and to high satisfaction rates. Hence, either approach can be used to deliver live, web-based, RT group sessions, to overcome certain barriers to participation in RT.

Trial registration: clinicaltrials.gov (NCT04895865).

Keywords: adherence, autonomy, repetition-prescription, resistance-training, tele-health.

1. Introduction

Resistance training (RT) has many health benefits, such as reducing the rates of different diseases and all-cause mortality [1,2]. While health organizations recommend two weekly session of RT [3,4], only 17% to 30% of the population follow this guideline [5,6], and even less so during the Covid-19 pandemic [7]. A possible explanation for the low RT participation rates is the insufficient way the traditional RT prescription approach accounts for differences in trainees' abilities [8–10] and preferences [11,12]. Specifically, the resistance which trainees are expected to use is commonly fixed and predetermined, often calculated as a percentage of the maximal load that can be lifted once (i.e., one repetition maximum [1RM])[1]. The number of repetitions prescribed per set is also commonly fixed [4,13]. For example, novice trainees are recommended to use resistance equivalent to 60%-70% of 1RM, and perform ten repetitions per set [13]. Even when using the same relative resistance (e.g., 70%1RM), the maximum number of repetitions that trainees can complete differs considerably [8,9]. This could lead to inconsistencies in the difficulty level experienced by trainees who follow the same program. Moreover, some trainees may prefer to use lower resistance and complete more repetitions, whereas others may prefer the opposite. While considering one's preferences have a range of benefits [12,14,15], the traditional approach does not sufficiently account for it. Collectively, the generic nature of this approach may contribute to the low RT participation and adherence rates.

An alternative to the traditional approach is to prescribe RT using single-item rating of perceived effort (RPE) scales [16,17] that typically range from zero ("no effort") to ten ("maximum effort"). RPE can be used to prescribe RT using two approaches: fixed-repetition and open-repetition. Following the fixed-repetition approach, trainees are guided to select the resistance that would result in a certain RPE after completing a predetermined number of repetitions [18]. For example, reaching a RPE of 7/10 by the final, 10^{th} repetition. If RPE is too low or too high by the end of the set, trainees adjust the resistance for the subsequent sets (i.e., load when using weights, tension when using resistance bands, or body position when performing calisthenics). Following the open-repetition approach, trainees are guided to terminate a set once they have reached a certain RPE, independent of how many repetitions are required to reach that value [17]. For example, terminating a set when reaching a RPE of 7/10 may lead to eight repetitions

[1] While RT is commonly associated with the implementation barbells and dumbbells, RT can also be performed with one's bodyweight, resistance bands, and more. Hence, in this article we use the term resistance to include all possibilities that can be implemented in RT.

for one person and 16 for another. Note that one can reach the same RPE by using greater resistance coupled with fewer repetitions, or by using lighter resistance coupled with more repetitions. While both fixed-repetition [18–20] and open-repetition [17] RPE approaches have been studied, the former has been studied more extensively.

Both RPE-based prescription approaches account for individual abilities by having trainees make certain adjustments to RT variables during the sessions, but each approach has unique benefits. Under the fixed-repetition approach, trainees know exactly how many repetitions they are required to complete, which improves performance compared to less certain set endpoints [21,22]. However, trainees are required to anticipate what their RPE will be by the end of the set before it begins – a task that may be difficult to attain with sufficient accuracy [23]. Under the open-repetition approach, trainees complete as many repetitions as required until reaching a target RPE, using either a predetermined or a self-selected resistance. When allowing trainees to self-select the resistance, the open-repetition approach can better account for individual preferences. This is because some may prefer to perform a set composed of higher resistance coupled with fewer repetitions, and others may prefer the opposite. Since the exact combination of resistance and repetitions is of lesser importance to gain RT benefits provided that sufficient effort is invested in each set [24–26], trainees can select their preferred combination. When following the open-repetition approach, trainees continuously monitor their effort and terminate the set when they reach the target RPE, hence no anticipatory decisions are required. However, participants are deprived of a clear set endpoint. While both the fixed and open repetition RPE prescription approaches have unique advantages in personalizing RT programs, to date, no study compared between them.

Alongside the rigidness associated with traditional RT prescription approaches, other factors may negatively affect RT participation rates: lack of time, absence of instructions on exercise execution and progression, and shortage of equipment and facilities [11]. These factors can be addressed by delivering live, online, home-based RT sessions using a resistance band. Using videoconferencing to deliver training sessions is a safe, convenient, and a cost-effective method [27] that has gained popularity during the Covid-19 outbreak [28]. Resistance bands are affordable, consume little space, and can be as effective as other modalities in eliciting strength gains [29]. Hence, the aim of this study was to compare between the fixed and open repetition RPE based RT prescription approaches, delivered online and using resistance bands, on

adherence rates, body composition, performance, and psychological outcomes, among healthy young adults.

2. Methods

2.1 Design

A parallel arm randomized controlled trial was implemented and conducted in Israel. The study was approved by the Ethics Committee of Tel-Aviv University (approval number: 0002205-1).

2.2 Participants

We aimed to recruit a total of 60 participants (30 per group) based on our resources [30], and previous experience with this type of intervention [17]. Additionally, we were limited in our ability to test more than 60 participants in a two-week period in the pre- and post-tests, and also expected that 30 per group would allow the instructor to oversee all participants. Eligible participants included healthy, sedentary, adults (ages: 18-45) with no RT experience. Exclusion criteria were any co-morbidities preventing participation in the program, routine use of prescription medication, pregnancy, or delivery within the past six months. Participants were recruited through different social media channels (e.g., Facebook and Instagram). Eligible participants were provided with general information about the study and underwent a health screening using the Physical Activity Readiness Questionnaire [31] translated to Hebrew by the Israel Ministry of Health. Eventually, 57 participants were block-randomized based on their age and gender to one of two groups: fixed-repetitions RPE (10 males and 18 females, age: 35±7, weight: 71±16, height: 168±7) or open-repetitions RPE (12 males and 17 females, age: 35±7, weight: 74±20, height: 169±11) (see the participant flow chart in Figure 1).

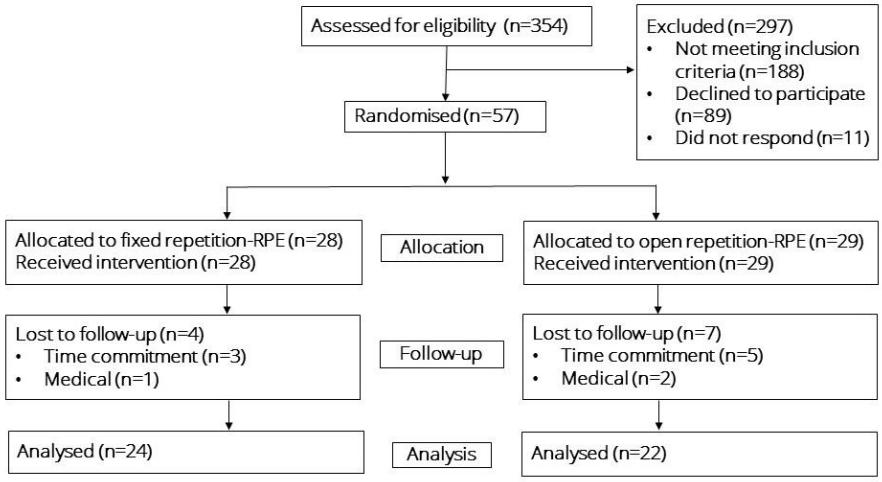

Figure 1. Participant flowchart.

2.3 Procedures

The RT protocols were developed by the research team over a period of two months that included regular meetings and pilot work. A detailed account of the development process and justification for the inclusion of each part can be found in the supplementary section. Participants first received three short videos (3-5 minutes) explaining the testing procedures, the RT protocol, and an overview of how to modify exercise intensity using RPE. They then participated in a pre-test session that included anthropometric and performance measurements at the exercise science laboratory at Tel-Aviv University. After signing the consent form, an examiner provided each participant with a resistance band (NT Loop, Florida, United States). Two different resistance levels were available for the band; men received the high resistance band while women received the low resistance band. The examiner instructed participants on how to properly complete the exercises and how to use RPE for intensity regulation. If participants did not watch the videos at home, they were required to watch them at the beginning of the session. Body composition measurements were taken, followed by a global warm up prior to the performance measurements. Each performance measurement began with a specific warm up using RPE to regulate intensity and to allow for a deeper understanding of how to use RPE. The post-test session resembled the pre-test excluding the instructional component. The pre- and post-test sessions lasted approximately 90 and 50 minutes, respectively. Data were collected at a similar time of the day for each participant (±2 hours). Participants followed a specified liquid protocol to ensure reliable body composition data (see anthropometric measurements section 5.2.2).

2.4 Intervention

2.4.1 Effort regulation

Participants were explained that effort is the process of investing mental and physical resources in a task [32]. It was explained to them that during the sessions, they would be requested to invest a pre-specified level of subjective effort during a set, estimated with a zero to ten RPE scale. In this scale, zero corresponds to investing no resources at completing the task (no effort) and ten corresponds to investing all available resources to complete the task (maximal effort). More specifically, ten corresponds to attempting to, but not being able to produce, greater forces in the isometric exercises (e.g., isometric knee extension); attempting to, but not being able to complete, another full range of motion repetition in the dynamic exercises (e.g., push up); or attempting to, but not being able to jump any higher, in the jumping test. To ensure adequate understanding of the instructions, the explanations were repeated and practiced

throughout the pre-test session. This was done by using RPE guided warmups for each isometric measurement prior to reaching maximal efforts (i.e., complete each task at a RPE of 4,7,9 and 10). Brief reminders about RPE and how to implement it were also delivered throughout the training sessions.

2.4.2 exercise protocol

The intervention lasted eight weeks and included two exercise classes a week lasting ~45 minutes on Mondays and Thursdays starting at 19:30 and 20:30. To avoid a time effect bias, each group completed one session a week at 19:30 and another at 20:30. The classes were delivered online using Zoom video communications (California, USA) by the first author – an experienced physiotherapist and personal trainer. Participants were instructed to select a viewing mode in Zoom that only presented the instructor (i.e., "speaker mode"). While the instructor provided motivational general feedback and instructions, to avoid various biases, the feedback was not personal and did not include participants' names. The instructor used WhatsApp group chats (Meta, Ca, USA) to deliver updates and reminders. In both groups, the structure of the sessions was similar: 4-6 minutes of warm-up, 25-35 minutes of moderate-intensity exercises using the resistance band and body weight exercises, and 5 minutes of cool-down (see supplementary materials for the Consensus on Exercise Reporting Template Table). A video demonstration of the exercise protocol is available at https://youtube.com/playlist?list=PL4BdVVEc6Cb018TBa9vyl_xCTy8QA6T38).

Table 1. RT intervention protocol and progression. Note that the participants were able to modify the exercise difficulty level by changing the tension in the resistance band and/or range of motion.

Pair #	Exercise		Weeks			
			0-2	2-4	4-6	6-8
1	Squat	Standing row	2 sets	3 sets	2 sets	2 sets
2	Dead lift	Push up	2 sets	2 sets	2 sets	2 sets
3	banded side steps	Shoulder abduction	2 sets	3 sets	2 sets	3 sets
4	Sumo-squat	High pull			2 sets	3 sets
5	Biceps curls	Trunk rotation	2 sets	2 sets	2 sets	2 sets
	Isometric plank				2 sets of 30 s	2 sets of 45 s

Certain aspects of the protocol were modified approximately every two weeks following the research team meetings, and after reviewing the semi-monthly surveys (see section 2.5.4 for questionnaire details). The groups differed in the RPE approach used by the participants. Participants in the fixed-repetition group were instructed to complete ten repetitions per set and exercise, while aiming to reach a RPE of 7/10 at the 10^{th} repetition. Thus, participants had to select and adjust the band resistance or their body orientation, to achieve this goal. Conversely, participants in the open-repetition group were instructed to complete as many repetitions as required to reach the target RPE of 7/10 by the end of the set, using whichever resistance they preferred. Hence, participants could have selected lower resistance and completed more repetitions, selected higher resistance and completed fewer repetitions, or any other combination they preferred. Participants were also encouraged to vary and explore the different combination between sets and exercises within and between the sessions. In both cases, participants were asked to adjust the resistance between and not during the sets.

2.5 Outcome measures

2.5.1 Adherence: The instructor documented the attendance of each participant in each session for each group. Adherence was calculated as the number of participants who attended a session, divided by the total number participants in each group. This was done for each of the 16 total sessions.

2.5.2 Anthropometric measurements: included weight, height, BMI, and fat free mass (FFM). Standing height was calculated using a SECA stadiometer. Weight and bioimpedance was measured using the SECA mBCA 515 (SECA, Hamburg, Germany), a valid and reliable analyzer of body composition [33]. For reliable and consistent measures, participants were requests to avoid alcoholic beverages 24 hours before measurements, to avoid caffeinated products two hours prior to the session, and to drink at least 400 ml of water up to 30 minutes before the test and to urinate immediately before the measurements. Participants reported liquid consumption (e.g., amount of water glasses consumed, any deviation from protocol) this was recorded and repeated at post-test.

2.5.3 Performance measurements: Participants warmed up for five minutes with dynamic stretching and calisthenics, and then performed a specific warm up for each of the five tests. Excluding the push up test, the specific warm up consisted of completing the tests with progressively higher efforts (i.e., 2, 2, 1 repetitions corresponding to an RPE of 4, 7, 9, respectively) prior to completing the tests with maximal effort (i.e., RPE of 10). For each test, participants completed three attempts of maximal effort, or a fourth one if their results

continued to improve above 5% relative to any of the previous attempts. Each isometric contraction lasted five seconds with two-minutes of rest between attempts. The mean value of the two highest scores was analyzed. All force data were recorded using the Kforce pro app (Kinvent, Orsay, France). For the push up tests, the maximal number of repetitions was recorded and analyzed. Performance measurements were performed in the following order.

Isometric mid-thigh pull (IMTP): The IMTP was performed with participants standing on a commercially available portable force plate (Deltas, Kinvent, Orsay, France) to record ground reaction forces at a sampling frequency of 500 Hz. Participants applied force into the ground by pulling a barbell that was secured by ratchet straps to a Smith machine (Insight Fitness, DR030B). Bar height was set to midthigh and was personalized by measuring a hip and knee angle of 135°-150° and 125°-150°, respectively, using a goniometer. Participants were asked to hold the bar at shoulder width using an overhand grip which remained constant across the two testing sessions.

Counter movement jump (CMJ): CMJ was measured with the same force plate. Participants were asked to jump as high as possible with their hands on their waist. No restriction was imposed on how low they could squat before jumping. Maximal jump height (cm) was collected and determined by the vertical velocity of the center of mass at takeoff, calculated by double integrating the vertical ground reaction force through the impulse momentum method.

Hand grip strength: Participants were seated on a stable chair without arm support. They were requested to hold the grip dynamometer (Kinvent, Orsay, France) with their dominant arm (defined as writing hand) in an extended position while their non-dominant arm was placed across their chest and legs supported on the floor.

Isometric knee extension: Participants were seated on a large stable table without back support with the knee of their dominant leg (defined as the leg used to kick a ball) at an angle of 100-110°, as measured with a goniometer. Their shin was inserted into a padded strap which was attached to a load cell (Kinvent, Orsay, France), secured to the other end of the table.

Push-ups: Participants were asked if they think they can complete horizontal push-ups on the floor. Based on their answer, participants either completed the test horizontally on the floor, or in a positive inclination that was individualized per participant by modifying the height of the Smith machine barbell on which the test was completed. Once the appropriate inclination was identified, 5-8 repetitions were completed as part of the warmup. To ensure full range of motion, a padded box (10 cm) was placed under participant's chest, which they were requested to lightly touch with every repetition. Following a two-minute rest, participants were asked to complete as many push-ups as possible, corresponding to a RPE of ten. If participants completed two

repetitions in a row with limited range of motion, the test was stopped, and the last repetition performed was documented.

2.5.4 Questionnaires: During the intervention, participants answered 11 online questions every other week (Qualtrics XM Platform, Utah, USA). The questions were composed of three general satisfaction categories: 1) the exercise program, 2) the ease of using RPE as a tool to modify exercise intensity, and 3) the online setup, including the quality of the sound and video. Answers were provided using a visual analog scale (VAS) ranging from -100 (low/negative) to 100 (high/positive), since these scales are recommended for online platforms and are better suited to be treated as a continuous variable in statistical analyses than Likert scales [34,35]. The following statements were included: 1. "Participating in the exercise program is a positive experience". 2. "I exercised according to my preferences". 3. "The way I exercise is aligned with my interests". 4. "I feel that I have the opportunity to make choices with regard to the way I exercise". 5. "Regulating workout intensity using the RPE is clear to me". 6. "I can successfully regulate the exercise intensity using RPE". 7. "I am satisfied with the variety of exercise selected in the program". 8. "I find the resistance band comfortable to use". 9. "Your enjoyment level from the last 4 sessions attended". 10. "Your experience with zoom – video and audio quality". 11. "Your experience with zoom – communication with the instructor".

2.6 Statistical analysis

We tested the normality of the data via kurtosis and skewness inspection, in which skewness < 2 and kurtosis > 7 were considered as substantial deviations from normality [36]. In case that the normality assumption was not violated, we presented the data as mean ± standard deviation (SD). Adherence rates were analyzed by repeated measures ANOVA with the within-subjects effect of time (16 RT sessions) and the between-subjects effect of group (fixed-repetition/open-repetition). To examine if difference occurred between groups in body weight and composition, as well as the five performance tests, we ran ANCOVAs, in which the post-test result was the dependent variable, the group was an independent variable, and the pre-test result, age and sex were used as the covariates. Additionally, we used independent t-tests to evaluate the change score (post-pre) differences between groups, and paired t-tests to evaluate the differences between pre and post results within each group.

To analyze the questionnaire data, we first conducted a principal component analysis on the 11 items with oblique rotation (direct oblimin) at the first time point. We used the Kaiser–Meyer–Olkin (KMO) measure to verify the sampling adequacy for the analysis (KMO =0.66), and that all

KMO values for individual items were greater than 0.5. We retained three components that explained 69% of the variance. The items that cluster on the same component suggest that component-1 represents general satisfaction from following the exercise program, component-2 represents satisfaction from using the RPE to regulate effort, and component-3 represents satisfaction from using the online platform. The average scores of items that cluster on the same component were calculated at every time point (satisfaction-program, satisfaction-RPE, satisfaction-technological). As the scores violated the normality assumption, they were compared by non-parametric tests. We compared the scores between the two groups by Mann-Whitney U test at each of the four time points. Then, the differences between the scores measured at four time points were analyzed by Friedman's two-way ANOVA.

Conservative multiple comparison adjustment to p-values was performed using the Holm-Bonferroni correction. Differences were considered statistically significant when the corresponding p-values were <0.05. When relevant, 95% confidence intervals (CIs) were reported. All statistical analyses were conducted using SPSS (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 28.0. New York, USA). For reproducibility purposes all the raw data can be found in the following link https://.osf.io/x6g45.

3. Results

Adherence rates: When including all 57 participants in the analysis, the average adherence rates across sessions was 60% in the fixed-repetition and 56% in the open-repetition groups. No statistically significant differences were found between groups ($F(1, 54) = 0.235$, $p = 0.630$, $\eta^2 = 0.001$), nor an interaction between groups and time ($F(15, 810) = 0.939$, $p=0.520$, $\eta^2 = 0.011$). However, a statistically significant effect of time was observed ($F(15, 810) = 8.323$, $p<0.001$, $\eta^2 = 0.094$) in which adherence rates decreased from approximately 90% at the first session, to 40% by the 16th session (Figure 2).

When excluding ten participants from the analysis (three from fixed and seven from open-repetition groups) who did not attend 20% of the sessions (3/16), adherence rates across sessions increased to 66% in the fixed-repetition and 71% in the open-repetition group. No statistically significant differences were found between groups ($F(1, 45) = 0.951$, $p = 0.391$, $\eta^2 = 0.002$), nor an interaction between groups and time ($F(15, 675) = 0.975$, $p=0.480$, $\eta^2 = 0.018$). A statistically significant effect of time was observed ($F(15, 675) = 6.155$, $p<0.001$, $\eta^2 = 0.103$) in

which adherence rates decreased from approximately 91% at the first session, to 51% by the 16th session.

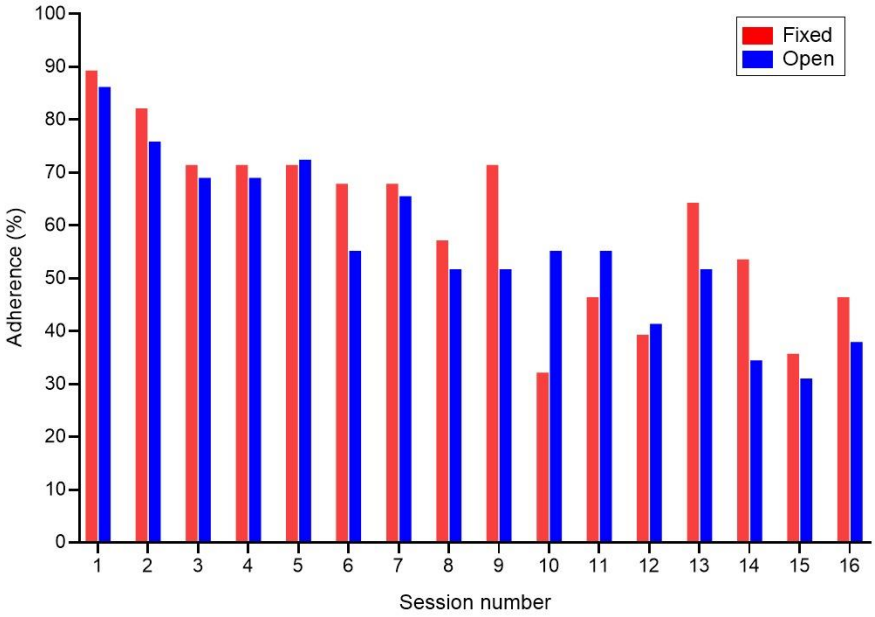

Figure 2. Adherence rates including all participants (n=57) across groups and sessions

Body weight, composition and performance test: Of the 57 participants who began the study, 11 did not attend to the post-test session (four from the fixed group, and seven from the open group). Their data was thus excluded from the body composition and performance test analysis. While no significant effect of group was observed for any of the variables, some improvements from pre- to post-tests were observed (Table 2 and 3).

Table 2. Descriptive statistics of the pre and post intervention results in body composition and performance outcomes in each group and across groups.

	Fixed-repetition (n=24)		Open-repetition (n=22)		Both (n=46)	
	Baseline Mean ± SD	8 weeks Mean ± SD	Baseline Mean ± SD	8 weeks Mean ± SD	Baseline Mean ± SD	8 weeks Mean ± SD
Body weight (kg)	73.4±17.1	73.0±17. 6	71.1±18.6	71.2±18.2	72.3±17.7	72.1±17.7
Fat free mass (kg)	47.1±10.8	47.5±10.7	50.8±14.0	51.1±13.3	48.9±12.4	49.2±12.0

BMI (kg/m²)	25.8±5.6	25.6±5.7	24.6±4.4	24.7±4.2	25.2±5.05	25.1±5.03
IMTP (kg)	183.6±40.6	189.8±48.2	197.2±63.3	201.9±60.0	190.1±52.6	195.6±53.9
Jump height (cm)	20.6±5.4	21.0±5.2	24.4±7.2	24.9±7.5	22.3±6.5	22.8±6.6
Grip force (kg)	27.3±7.6	27.0±8.02	28.3±9.4	29.1±9.7	27.8±8.5	28.0±8.8
MVC knee (kg)	35.6±11.5	37.9±10.4	40.7±16.4	42.8±17.7	38.0±14.1	40.3±14.4
Pushups (reps)	17.7±9.6	24.5±11.9	17.7±6.9	23.6±8.8	17.7±8.3	24.1±10.4

Table 3. Inferential statistics for the body composition and performance tests between groups (ANCOVA and unpaired t-tests on change scores) and within groups (paired t-tests on pre and post test results) analysis. P values, point estimate and 95%CI are reported.

	Between group differences		Within (post-pre) group differences		
	Fixed–Open (ANCOVA)#	Fixed–Open (unpaired t-test)	Fixed-repetition (n=24)	Open-repetition (n=22)	Both (n=46)
Body weight (kg)	p=0.57 0.30 (-0.77, 1.38)	p=0.38 -0.44 (-1.47, 0.57)	p=0.24 -0.43 (-1.16, 0.31)	p=0.95 0.02 (-0.72, 0.77)	p=0.40 -0.21 (-0.72, 0.29)
Fat free mass (kg)	p=0.84 0.06 (-0.53, 0.64)	p=0.83 0.06 (-0.53, 0.65)	p=0.04 0.33 (0.01, 0.65)	p=0.30 0.27 (-0.26, 0.80)	p=0.04 0.31 (0.01, 0.59)
BMI (kg/m²)	p=0.34 0.18 (-0.20, 0.57)	p=0.18 -0.24 (-0.62, 0.12)	p=0.14 -0.20 (-0.46, 0.07)	p=0.70 0.05 (-0.22, 0.32)	p=0.41 -0.08 (-0.26, 0.10)
IMTP (kg)	p=0.93 0.41 (-9.18, 10.00)	p=0.76 1.45 (-8.18, 11.1)	p=0.09 6.23 (-1.07, 13.52)	p=0.15 4.77 (-1.85, 11.39)	p=0.02 5.53 (0.76, 10.39)
Jump height (cm)	p=0.61 0.35 (-1.05, 1.74)	p=0.84 0.12 (-1.41, 1.74)	p=0.97 0.39 (-0.26, 1.06)	p=0.37 0.53 (-0.68, 1.73)	p=0.15 0.45 (-0.17, 1.09)
Grip force (kg)	p=0.35 0.75 (-0.84, 2.36)	p=0.19 -1.03 (-2.58, 0.52)	p=0.62 -0.28 (-1.45, 0.89)	p=0.16 0.74 (-0.32, 1.82)	p=0.60 0.20 (-0.57, 0.99)
MVC knee (kg)	p=0.98 0.04 (-3.01, 3.17)	p=0.91 0.16 (-2.72, 3.1)	p=0.04 2.29 (0.14, 4.43)	p=0.04 2.12 (0.08, 4.15)	p=0.003* 2.21 (0.78, 3.64)
Pushups (reps)	p=0.55 -1.13 (-4.97, 2.71)	p=0.60 0.97 (-2.72, 4.66)	p<0.001* 6.83 (4.06, 9.6)	p<0.001* 5.86 (3.28, 8.44)	p<0.001* 6.36 (4.53, 8.20)

* Statistically significant results at the significance level of 5% according to Holm-Bonferroni method.

The coefficient of group variable in the ANCOVA model where the fixed-RPE group was used as a reference line.

Questionnaires: Participants that attended less than three sessions (n=10) were excluded from this analysis as the questionnaires concerned the evaluation of the program on an ongoing basis (e.g., "Your enjoyment from the last four sessions attended"). Excluding one significant difference between groups in the technological satisfaction factor at time-3, favoring the fixed-repetition approach, no significant differences were observed between groups across time points using

the Mann-Whitney U test (Figure 3). We analyzed the aggregated data of the two groups (each time point included 35-45 responses per component), and compared the calculated scores between the four time points using Friedman's two-way ANOVA. Excluding one significant difference in the RPE factor between time-2 and time-1, we observed no significant differences between the scores within each factor across time points (Figure 3). The median satisfaction rates in all components, across groups and time points, ranged between 44 to 100 in the -100 to 100 VAS scale.

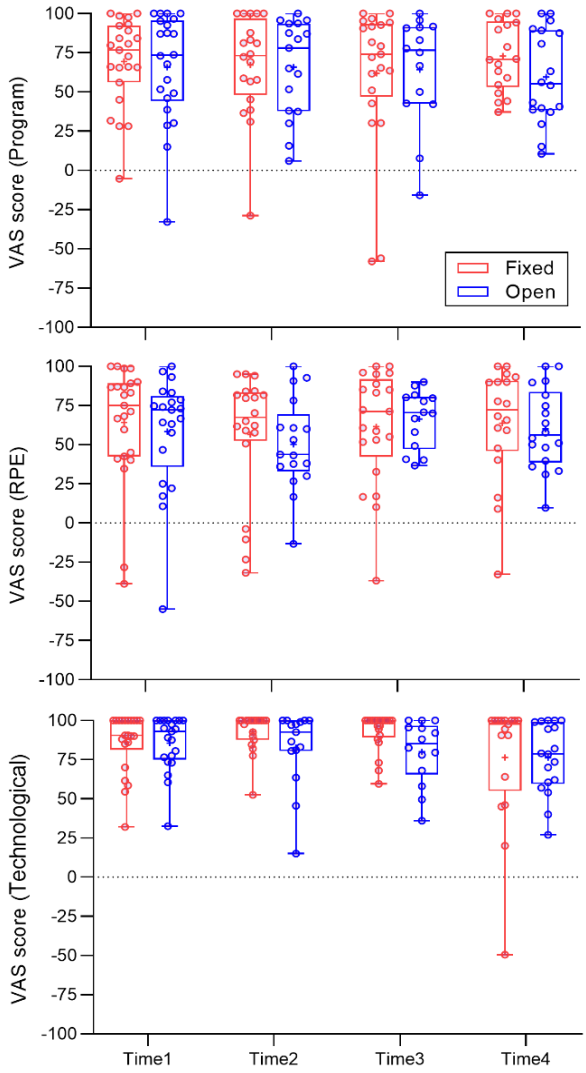

Figure 3. Questionnaires data across the four time points presented in box plots (horizontal line indicates median and plus sign indicates mean) with minimum to maximum error bars in addition to individual data points.

4. Discussion

We compared two RPE based approaches to prescribe RT intensity during live, web based, group RT sessions, over a period of eight weeks, among a cohort of participants with limited experience in RT. We collected and compared adherence rates, body composition, performance outcomes and various questionnaires. Under the fixed-repetition approach, participants selected the resistance to reach a RPE of 7/10 by the end of a set composed of ten repetitions. Under the open-repetition approach, participants selected their preferred resistance and completed as many repetitions as required until reaching a RPE of 7/10. Whereas the results of all outcomes were similar between groups, both led to acceptable adherence rates, and improvements in body composition, some performance tests, and to high satisfaction rates. Overall, these results suggest that both RPE prescription approaches can be used to deliver live, online RT sessions, to increase participation rates in RT among the general population.

We sought to examine if the unique benefits of the fixed and open repetitions RPE approaches would lead to different effects. No meaningful differences were observed between the two groups in any of the outcomes. While the lack of differences may stem from the small sample size and the relatively short duration of the intervention, the overall results may have practical implications. Primarily, implementation of a specific RPE prescription approach can be based on participant's preferences. Indeed, it is reasonable to expect that matching the RT prescription approach to one's preferences may positively impact enjoyment and adherence rates [14,15,37]. To illustrate, in two recent studies from our laboratory, participants completed RT protocols in which the number of repetitions was fixed, self-selected out of range [38], or based on one's ongoing RPE [39], In both studies we observed that approximately half of the participants emphasized the importance of having a clear set endpoint, whereas the other half emphasized the importance of having control over when to terminate a set based on their ongoing perceptions [39]. Whereas in the current study participants were randomized into one of the two groups, future research could inspect the effects of allowing participants to exercise

according to their preferred approach. It is possible that doing so will lead to more favorable outcomes.

Across the two groups, adherence levels began at approximately 90% and decreased over time to 50%. It is challenging to compare this result to other studies given the differences in the population, length of study, exercise modality, etc. Yet, adherence rates in the current study fall within a comparable range reported in similar studies [17,40,41]. Participants in both groups also rated the program as enjoyable and reported high perceptions of autonomy. This is an encouraging finding given that both enjoyment levels and perception of autonomy are associated with higher adherence rates [15,42]. Participants increased their FFM and improved their performance in the IMTP, isometric knee extension and the push-ups test. Conversely, grip strength and countermovement jump height remained unaffected by the intervention. These results are mostly in line with studies that implemented similar designs [43,44]. Collectively, the interventions had a positive impact on the range of performance and psychological outcomes, and can be used in future studies or in practice.

Several methodological concerns of this study are worthy of discussion. First, the time of day on which the sessions took place were predetermined by the research team. The selected hours, especially the 19:30 to 20:15 session, were noted as problematic, especially for participants with children. Second, to avoid various biases, the verbal feedback provided by the instructor did not include personal feedback. To illustrate, in case the instructor spotted a participant completing an exercise with faulty technique, she provided a general feedback statement to all participants regarding how the exercise should be performed without mentioning the participant's name. Additionally, participants were instructed to select "speaker mode" in Zoom. The absence of personal feedback and the inability to view and relate to the other group members may have negatively impacted adherence and affective responses. Future research aiming to implement similar designs should consider these points when planning the study.

In conclusion, we observed that both RPE prescription approaches elicited similar effects across outcomes. In both groups, adherence rates gradually declined over the study's duration. Participants somewhat increased their fat free mass, improved performance in some of the outcomes, and enjoyed exercising according to the protocol. While some aspects of the protocol may require modifications in the future, such as the time of the day the classes take place, and

the type of feedback provided, the intervention can be viewed as a simple and mostly effective in increasing RT participation rates among the general population.

Authors' contributions

IH, I.HN, HS, and Y.BZ, designed the study, Y.BZ, HS, and I.HN collected measurements data, Y.BZ delivered the intervention, NB and IH analyzed the data, Y.BZ, H.S, NB and IH wrote the manuscript. All authors have read and approved the final version of the manuscript.

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Data and supplementary material accessibility

Supplementary materials are available at https://osf.io/x6g45 and include intervention development appendix, consensus exercise reporting and excel data file for reproducibility purposes.

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