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SYSTEMATIC REVIEW

Are Trainees Lifting Heavy Enough? Self-Selected Loads in Resistance Exercise: A Scoping Review and Exploratory Meta-analysis

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Abstract

Background Traditionally, the loads in resistance training are prescribed as a percentage of the heaviest load that can be successfully lifted once (i.e., 1 Repetition Maximum [1RM]). An alternative approach is to allow trainees to self-select the training loads. The latter approach has benefits, such as allowing trainees to exercise according to their preferences and negating the need for periodic 1RM tests. However, in order to better understand the utility of the self-selected load prescription approach, there is a need to examine what loads trainees select when given the option to do so.

Objective Examine what loads trainees self-select in resistance training sessions as a percentage of their 1RM.

Design Scoping review and exploratory meta-analysis.

Search and Inclusion We conducted a systematic literature search with PubMed, Web of Science, and Google Scholar in September 2021. We included studies that (1) were published in English in a peer-reviewed journal or as a MSc or Ph.D. thesis; (2) had healthy trainees complete at least one resistance-training session, composed of at least one set of one exercise in which they selected the loads; (3) trainees completed a 1RM test for the exercises that they selected the loads for. Eighteen studies were included in our main meta-analysis model with 368 participants.

Results Our main model indicated that on average participants select loads equal to 53% of their 1RM (95% credible interval [CI] 49–58%). There was little moderating effect of training experience, age, sex, timing of the 1RM test (before or after the selected load RT session), number of sets, number of repetitions, and lower versus upper body exercises. Participants did tend to select heavier loads when prescribed lower repetitions, and vice versa (logit(yi) = − 0.09 [95% CI − 0.16 to − 0.03]). Note that in most of the analyzed studies, participants received vague instructions regarding how to select the loads, and only completed a single session with the self-selected loads.

Conclusions Participants selected loads equal to an average of 53% of 1RM across exercises. Lifting such a load coupled with a low-medium number of repetitions (e.g., 5–15) can sufficiently stimulate hypertrophy and increase maximal strength for novices but may not apply for more advanced trainees. Lifting such a load coupled with a higher number of repetitions and approaching or reaching task failure can be sufficient for muscle hypertrophy, but less so for maximal strength development, regardless of trainees' experience. The self-selected load prescription approach may bypass certain limitations of the traditional approach, but requires thought and further research regarding how, for what purposes, and with which populations it should be implemented.

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Key Points

Participants selected loads that are relatively light (~53% of 1RM) across various resistance exercises, irrespective of their training background, age, and sex.

Assuming sets are of low-medium repetition range (5–15), then such a load can be sufficient for muscle hypertrophy and strength gains for novices but may not be sufficient for more advanced trainees.

Assuming sets approach or are taken to task failure, then such a load can be sufficient for muscle hypertrophy, but less so for maximal strength development, independent of trainees' experience.

The lower selected loads can be partly explained by the vague instructions participants received regarding load selection, and the completion of a single session with the self-selected loads, in most of the analyzed studies.

The self-selecting loads prescription strategy should be explored in more complex and longitudinal studies in which participants are given clear instructions regarding the intensity of effort required for each set.

1 Introduction

Load prescription for different exercises is a key variable in resistance-training (RT) programs. Traditionally, loads are prescribed in a predetermined manner using certain percentages of 1 Repetition Maximum (1RM) [3, 38, 53]. Trainees are required to complete periodic 1RM tests, or prediction tests of 1RM, in order to calculate the percentages of 1RM to be used in different exercises. For example, the American College of Sports Medicine (ACSM) recommends that novice to intermediate trainees use 60–80% of 1RM in their RT sessions for strength and hypertrophy improvements [3, 4, 38]. The traditional load prescription approach is effective and allows for accurate monitoring and progression of load over time; however, it has a number of shortcomings. While 1RM tests are considered safe and reliable [31], they are time-consuming, can require monitoring and assistance, and may be intimidating for the inexperienced [46]. Moreover, 1RM results are influenced by a wide variety of variables, such as the type of warm-up [1], the number of observers [52], feedback, and instructions [59]. Imprecise 1RM results can bias the percentage of 1RM used for the training program, leading trainees to follow a different program than was intended.

Under the traditional approach, loads are commonly prescribed from a narrow range of 1RM (e.g., 60–80% 1RM) without explicitly considering the trainees' load preferences [3, 4, 38]. Yet, some trainees may prefer to use relatively heavier loads coupled with fewer repetitions, whereas others may prefer the opposite. Allowing trainees to choose their preferred load can be a sensible strategy since a range of loads can improve a range of outcomes given that sufficient intensity of effort is invested (i.e., reaching or approaching task failure in sets) [41, 51, 56, 57]. Choice provision regarding different training variables can elicit positive affective responses [23, 61, 62] and improve motor performance compared to a no-choice condition or group (yet see [8, 50, 68] for similar outcomes between choice and no-choice condition or group). Examples of choice provision in RT include allowing trainees to select the number of repetitions (10, 15, or 20 repetitions) [43], the order of weekly RT sessions [8], and the exercise to be performed [50]. Allowing trainees to select their preferred load can potentially enhance their affective responses and motor performance while negating the need to prescribe load based on 1RM tests. However, prior to advocating for the self-selected load prescription approach, it is important to develop a clear understanding of what range of loads trainees select to lift when given the opportunity. For example, trainees may exercise at an insufficient intensity of effort if they select loads that are too light for a given repetition number.

A growing number of studies have examined what loads participants select in resistance exercises [11, 14, 16, 28]. However, these studies included participants of different ages, sex, and training experience. Participants in these studies were provided with different instructions on how to select the load, and then completed a dissimilar number of exercises, sets, repetitions, and sessions. A clear picture of what loads participants typically select remains elusive. Accordingly, the goal of this meta-analysis was to investigate what loads trainees self-select to lift across studies. We also examined if the following variables influence the selected loads: training experience, age, sex, timing of the 1RM test (before or after the self-selected load RT session), number of sets, number of repetitions, and lower versus upper body exercises.

2 Methods

2.1 Search Strategy

We conducted the systematic search and review according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Two reviewers (TM and IHN) performed electronic searches on Google Scholar, PubMed/MEDLINE and Web of Science, harvesting any data record up to September 20th, 2021. The search included the following terms: “self-selected” AND “resistance-exercise” OR "exercise-intensity*" OR "exercise-load" OR "training-load" OR "training-intensity" AND “intens*” OR “load*” AND "instruct*". We included studies if they met the following criteria: (1) published in English in a peer-reviewed journal, or as a MSc or Ph.D. thesis; (2) participants were healthy and completed at least one resistance-training session composed of at least one exercise in which they selected the loads; (3) participants completed a 1RM test for the exercises that they selected the loads for. Note that we included only the first session of studies that utilized long-term training interventions where participants self-selected loads. As such, only acute data were considered in the present paper.[1] Note that we did not include a methodological quality assessment of the included studies. This is because, beyond fulfilling the three criteria, other components of the study design and execution (e.g., randomization to groups) would not have affected our ability to answer the main question of this meta-analysis.

Two reviewers (TM and IHN) assessed relevant records, and downloaded them into Sciwheel.com [58]. To enable concurrent screening of titles and abstracts by the reviewers, potential records were uploaded to Abstrackr [66]. The full text article was assessed when both reviewers agreed an abstract indicated inclusion. Disagreements regarding the eligibility that arose between the reviewers was settled by IH.

2.2 Data Extraction

The following data were extracted from studies found to be eligible: title, participant’s characteristics of sample size, sex, age, training experience, exercises, sets, 1RM loads, selected loads, instructions, whether 1RM testing took place before or after load selection, and where reported, the number of repetitions performed. The main datum we were seeking to extract was self-selected loads as a percentage of 1RM, either obtained directly from the manuscript or calculated from the absolute 1RM and absolute self-selected loads reported. The data were extracted for all groups (separated by sex where possible) and conditions, across all exercises, sets, and sessions, within each study.[2] As such, there were multiple selected loads extracted for each included study in this analysis. Where data were not reported in this fashion (in some cases percentages or absolute loads were reported averaged across exercises/sets/sessions), one author (JS) emailed the authors of the manuscripts requesting the raw or mean values. A follow-up email was sent in cases where the authors did not reply within 2 weeks. If we were unable to obtain data in this fashion, we then included the averaged values for those studies if appropriate to the model (i.e., where data were averaged for moderators across exercises/sets/sessions—we excluded them from these models). We extracted the data to a csv file for meta-analysis (https://osf.io/9bqaz/) and to a Word table (Table 1).

2.3 Meta-analysis

All analysis codes utilized are presented in the supplementary materials (https://osf.io/54sq7/). Given the aim of this research, we opted to take an estimation-based approach [26], based within a Bayesian framework [39]. All analyses’ effect estimates and their precision, along with conclusions based upon them, were interpreted continuously and probabilistically, considering data quality, plausibility of effect, and previous literature, all within the context of each outcome [44]. The main exploratory meta-analysis was performed using the ‘brms’ package [6] with posterior draws taken using ‘tidybayes’ [36] and ‘emmeans’, and supplementary analyses conducted using the ‘metafor’ package in R (v 4.0.2; R Core Team, https://www.r-project.org/) [65]. All data visualizations were made using ‘ggplot2’ [69], and ‘patchwork’ [47].

Given that we were interested in the estimation of a continuous proportion, several options were available for our meta-analysis, including examining the raw proportions assuming normality, using the arcsine transformation, the logit transformation, or beta regression [13, 40, 67]. Ultimately, we opted to use the beta regression given it overcomes many problems with traditional approaches and transformations, although we also fit the aforementioned models as supplementary analyses for our main model to examine the sensitivity of findings to the model parameterization (see https://osf.io/n9s5v/ and https://osf.io/yvud4/).

[1] For chronic studies (i.e., training interventions) where the data were obtainable, we included an exploratory data visualisation in the supplementary materials (as opposed to the main paper) showing changes in load selection over time. Given the sparsity and heterogeneity of the data, despite attempting to fit a variety of models, we were unable to determine a model specification that resulted in clear convergence of Monte Carlo Markov Chains or reasonable posterior predictive checks. The data from these studies are descriptively presented with Loess smoothing across groups within studies and with gradient scaling for repetition groupings (< 5, 5 to 10, 10 to 15, and 15 to 20 repetitions) in the supplementary materials (see https://osf.io/q72ax/).

[2] We also coded studies as to whether they were acute (i.e., reported loads for a single session), or chronic (i.e., reported loads throughout a several sessions such as a training intervention). However, as noted above, the analyses presented in this manuscript relate only to the acute data (i.e., acute studies *and* the first session of chronic studies where the data were available) with any of the chronic data results (that are included in the supplementary materials).

Table 1 Summary of the methods and characteristics of the included studies

Article	Participants	Study design	Instructions	Sets and repetitions	Exercises
Alves, 2014 [2]	11F Age: 14 ± 2 Exp: novice	Days 1–2: familiarization Day 3: 1RM Day 4: SS loads	"How much weight would you select in this exercise to perform 1 set of 10 repetitions?"	3 × 10	Bench press Leg press Biceps curls
Dias, 2017 [12]	With personal trainer: 8 M/F Age: 24 ± 3 Exp: > 1 year W/out personal trainer: 13 M/F Age: 24 ± 2 Exp: > 1 year	Day 1: SS loads Day 2: 1RM	"Select a resistance they would typically use in their own workouts for completion of 10 repetitions (or until they reached failure)"	3 × 10	Leg press Bench press Knee extension Biceps curls
Dias, 2018 [11]	38 M/F Age: 23 ± 3 Exp: > 6 months	Day 1: SS loads Day 2: 1RM	"Participants were instructed to select a resistance intensity that provided a "good workout" for each exercise type"	3 × 10	Leg press Bench press Knee extension Arm curl
Elsangedy, 2013 [14]	20F Age: 66 ± 3 Exp: novice	Day 1: Familiarization Day 2: 1RM Day 3: SS loads	"Select a load for performing three sets of 10–15 repetitions of the (exercise name)"	3×10^{-15}	Bench press Leg press Lat pull down Leg extension Shoulder raise Knee curl Biceps curl Triceps extension
Elsangedy, 2016 [15]	12 M Age: 36 ± 6 Exp: novice	Day 1: Familiarization Days 2–3: 1RM Day 4: SS loads	"Participants were asked to self-select the load to complete 3 × 10 repetitions"	3 × 10	Bench press Leg press Seated row Knee extension Shoulder press Biceps curl Triceps extension
Elsangedy, 2018 [16]	16 M Age: 40 ± 7 Exp: novice	Days 1–3: familiarization Days 4–5: 1RM Day 6 and onward: 16 RT sessions	"Please, select a load associated with a [verbal descriptor of the Feeling Scale randomly selected for that day] feeling, corresponding to [numeral descriptor of the FS randomly selected for that day] on this scale for performing 3 × 10 on the [name of the exercise]"	3 × 10	Leg press Chest press Knee extension Biceps curl

Table 1 (continued)

Article	Participants	Study design	Instructions	Sets and repetitions	Exercises
Elsangedy, 2020 [17]	16F Age range: 60–72 Exp: novice	Weeks 1–2: Familiarization Weeks 3–4: pre-tests Weeks 4–16: SS RT Weeks 17–18: post-tests	"Please, select a load to perform 3 × 15. Before you start, you may perform two repetitions to gauge if the load fits your expectations. You can also adjust the load at the end of each recovery period if you desire"	3 × 15	Bench press Leg press Pull down Knee extension Lateral raise Knee curl Biceps curl Triceps extension
Faries, 2016 [20]	28F Age: 20 ± 1 Exp: novice	Day 1: 1RM Weeks 1–6: 3 RT sessions per week	"Select a load that you feel you should, to improve your muscular strength" Or "Select a load that is comfortable"	1 × SS number of repetitions	Bench press Shoulder press Triceps extension Lat pulldown Biceps curl Leg press
Focht, 2007 [24]	19F Age: 21 ± 3 Exp: novice	Day 1: 1RM Days 2–3: either 40% 1RM, 70% 1RM or self-selected load	"Subjects were instructed to select an appropriate resistance that would be comfortable to perform, yet still provide a good workout"	3 × 10	Knee extension Bench press Lat pull down Shoulder press
Focht, 2015 [23]	20F Age: 23 ± 3 Exp: ≥ 1 year	Day 1: 1RM Days 2–4: either 40% 1RM, 70% 1RM or self-selected load	"Participants were instructed to select a load that would be comfortable, yet still provide a good challenging workout"	3 × 10	Knee extension Bench press Knee curl Lat pull down
Glass, 2004 [28]	30 M/F Age: 19 ± 1 Exp: novice	Day 1: familiarization Days 2–3: SS loads Day 4: 1RM	"Choose a load that you feel sufficient to improve your muscular strength"	2 × SS number of repetitions	Bench press Knee extension Row Shoulder press Biceps curl
Glass, 2008 [29]	Control: 8 M/F Age: 21 ± 2 Exp: novice Experimental: 9 M/F Age: 21 ± 3 Exp: novice	Control: Day 1: familiarization Day 2: SS loads Day 3: 1RM Experimental Day 1: familiarization + 1RM in bench press Day 2: 2 sets of bench press to failure with 75%1RM Day 3: SS loads Day 4: 1RM	"Self-select a load that they felt would contribute to a gain in strength"	2 × SS number of repetitions	Bench press Leg press Lat pull down Triceps extension Biceps curl Shoulder press

Table 1 (continued)

Article	Participants	Study design	Instructions	Sets and repetitions	Exercises
Glass, 2020 [27]	SS group: 10 M/F Age: 20 ± 1 Exp: novice Imposed group: 10 M/F Age: 20 ± 1 Exp: novice	Day 1: familiarization Days 2–7: SS group: SS loads and repetitions numbers Imposed group: ~ 70%1RM for 12 repetitions Day 8: SS loads + 1RM for both groups	"Select a load that you feel will be enough weight to stimulate strength gain"	2 × SS number of repetitions	Bench press Leg press Shoulder press Biceps curl Triceps extension Pec fly Knee extension Lateral raise
Helms, 2018 [34]	10 M Age: 21 ± 1 Exp: > 2 years	Week 0: 1RM Weeks 1–8: SS RT Week 8: 1RM	"RPE group self-selected their loads to reach the target RPE range…"	2–3 × 2–8 Every 2 weeks the repetitions number decreased and load increased	Back squat Bench press
Helms, 2017 [35]	3F/9 M Age: 29 ± 4 Exp: 4.8 years	Week 0: 1RM Weeks 1–3: SS RT	"Select a load that you believe would result in the target RPE occurring"	Three conditions: 1–2 × 8 1–2 × 2 1–2 × 3	Back squat Bench press Deadlift
Ratamess, 2008 [49]	46F Age: 27 ± 1 Exp: 4.1 years	Day 1: SS load + 1RM	"How much weight would you select for this exercise if you were completing a 10-repetition set in your workout?"	1 × 10	Bench press Leg press Seated row Leg extension
Portugal, 2015 [48]	16 M Age: 25 ± 5 Exp: ≥ 3 months	Day 1: familiarization Day 2: 1RM Days 3–6: 40%, 60%, or 80% of 1RM and a SS load	"You are free to choose the workload that you prefer to perform eight repetitions. After each set, you may change the workload"	3 × 8	Pull down Knee extension Bench press Knee curl
VH de O Segundo, 2016 [9]	16F Age: 70 ± 7 Exp: none	Days 1–6: familiarization Days 7–8: 1RM Day 9: SS loads	"A weight training session with self-selected intensity through feeling scale where the load should be perceived as + 3 (good), corresponding to a comfortable condition of exercise"	3 × 10	Bench press Knee extension Lat pull down Knee flexion

Exp experience, *RM* repetition maximum, *RPE* rate of perceived effort, *RT* resistance training, SS self-selected

As the included studies often had multiple groups/conditions and reported effects within these for multiple sessions/exercises/sets—we opted to calculate effect sizes using a nested structure. Therefore, multilevel mixed-effects meta-analyses were performed with both inter-study and intra-study groups included as random effects in the model. Effects were weighted by inverse sampling variance to account for the within- and between-study variance (tau-squared). A main model included all selections made by all groups in each of the included studies. We conducted several exploratory meta-regression and sub-group analyses of moderators (i.e., predictors of effects) to explore study protocols and participant characteristics. Moderators examined using meta-regression included training experience, age, sex (for studies with male and female only participants), timing of the 1RM test, number of sets, number of repetitions, and lower versus upper body exercises. For both set number and number of repetitions performed we included random slopes for groups.

For all models, we used uninformed priors (due to the number of effects we anticipated that the likelihood would overwhelm posterior estimates anyway) and 23[3] Monte Carlo Markov Chains with 2000 warm-up and 6000 sampling iterations. Trace plots were produced to examine chain convergence and posterior predictive checks, which are included in the supplementary materials (https://osf.io/8qpgs/; see folder "Trace plots and posterior predictive checks"). Draws were taken from the posterior distributions to construct probability density functions for plotting. We then calculated the mean and the 95% quantile interval ('credible' or 'compatibility' interval) from the posterior probability density functions for each group effect estimate. These gave us the most probable value of the parameter, in addition to the range from the 2.5% to the 97.5% percentiles. Logits from the beta regression were back-transformed to the original proportion/percentage scale.

3 Results

3.1 Included Studies

After initial searches and screening, we identified 24 studies (13 acute, and 11 chronic) that met the inclusion criteria. Additional search approaches identified no further studies that met the inclusion criteria. From the chronic studies we could only obtain data of the first sessions from five of them [16, 17, 20, 34, 35]. Thus, there were 18 studies included in analyses [2, 9, 11, 12, 14–17, 20, 23, 24, 27–29, 34, 35, 48, 49]. Details of the search and inclusion process are shown in the PRISMA flow chart (Fig. 1). Details of the studies can be viewed in Table 1. Note that on some occasions, we observed minor discrepancies between the number of participants reported in the manuscripts and the raw data shared by authors. In such cases, we reported the number and characteristics of participants based on the raw data. Briefly, the pooled number of participants was 368 of which 137 were males (age: 28.83 ± 3.6 years, weight: 77.3 ± 11.9 kg, height: 171.84 ± 6.5 cm) and 230 were females (age: 29.3 ± 3.5 years, weight: 65.45 ± 10.23 kg, height: 164.9 ± 3.4 cm). Two hundred and four participants were complete novices, with no RT experience, and 163 had between 3 months to 5 years of RT experience. Full details of all included studies can be seen in the data extraction file (https://osf.io/9bqaz/).

3.2 Main Model: All Effects

The main model including all effects (283 across 28 groups and 18 studies) suggests that participants, on average, selected a load equal to 53% (95% CI 49–57%). Variance came primarily from the group level (https://osf.io/46zrm/). Figure 2 presents all effect sizes (ticks) and posterior probability distributions for each study, and the overall pooled estimate in an ordered forest plot.

3.3 Meta-regression Analyses

3.3.1 Training Status

Point and interval estimates were 52% (95% CI 47–58%) and 55% (95% CI 48–62%) for both untrained and trained participants, respectively (see Fig. 3).

3.3.2 Age

Age had a negligible impact on load selected with a slope of logit(yi) ≈ 0.00 (95% CI − 0.01 to 0.01) (see Fig. 4).

3.3.3 Sex

Sex had a small impact on load selected with point and interval estimates of 57% (95% CI 52–61%) and 49% (95% CI 45–53%) for both male and female participants, respectively (see Fig. 5).

3.3.4 Timing of 1RM

Point and interval estimates were 55% (95% CI 50–61%) and 51% (95% CI 45–57%) for both studies where the 1RM tests

[3] *C* -1 where *C* was the number of cores available on the computer used to run the analysis (build available here: https://uk.pcpartpicker.com/list/C6VXRT).

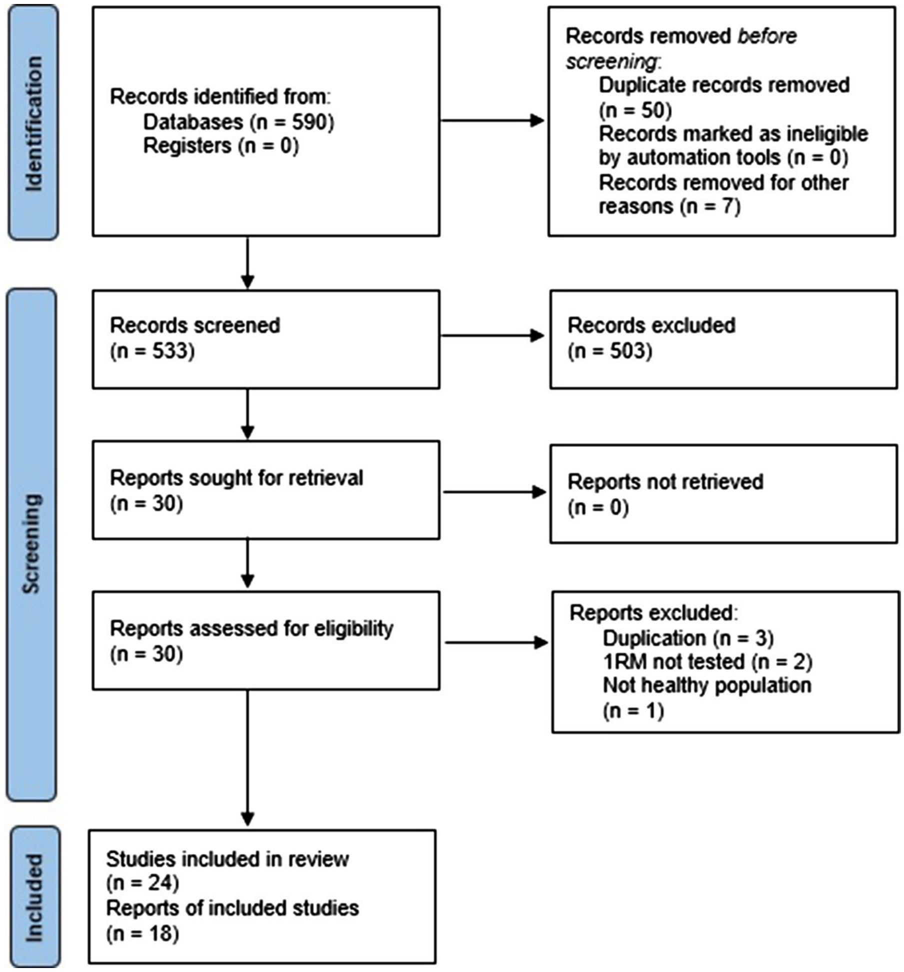

Fig. 1 PRISMA flow chart illustrating different phases of the search and study selection

were completed before and after the load selection session, respectively (see Fig. 6).

3.3.5 Set Number

Set number had a small impact on load selected with a slope of logit(yi) = 0.07 (95% CI 0.02–0.12) (see Fig. 7).

3.3.6 Number of Repetitions

Number of repetitions had an impact on load selected with a slope of logit(yi) = − 0.09 (95% CI − 0.16 to − 0.03) although, due to fewer effects at higher repetition numbers, interval estimates were imprecise at higher values (i.e., > 15 repetitions; see Fig. 8).

3.3.7 Upper and Lower Body Exercises

Point and interval estimates were 55% (95% CI 51–60%) and 49% (95% CI 45–54%) for both upper and lower body exercises, respectively (see Fig. 9).

4 Discussion

In this scoping review and meta-analysis, we explored what loads the participants chose to self-select to lift when performing resistance exercise. Across studies, participants selected loads that were equal to 53% of their 1RM, on average. We found little moderating impact of the following factors on self-selected loads: training experience, age, sex, whether the 1RM test was performed before or after the load selection session, number of sets, and whether upper or lower body exercises were performed. We found that participants tended to select the load based on the number of repetitions prescribed, with higher loads coupled with fewer repetitions and vice versa.

The authors of a number of the analyzed studies concluded that participants selected loads that are too light to improve maximal strength and hypertrophy. This conclusion is primarily based on the ACSM's recommendations, advocating loads of 60–80% of 1RM [4, 25, 38]. However, considering load independent of the number of repetitions, and proximity to task failure provides only a partial indication of potential training adaptations [21, 42, 45, 55]. If

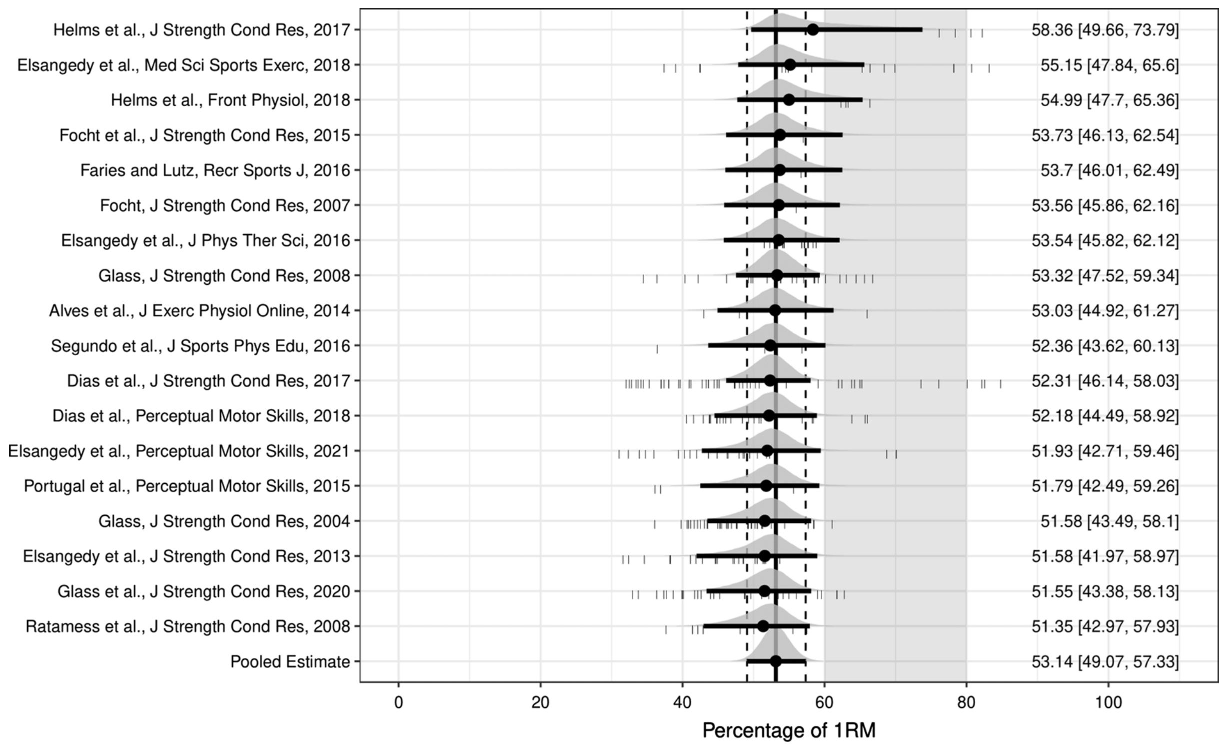

Fig. 2 Main model of all effects. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. The thick and dashed lines are the mean and compatibility intervals for the pooled estimate. Ticks below are the individual point estimates for effects within each study. The grey vertical band indicates the ACSM recommendation of 60–80% 1RM for visual reference

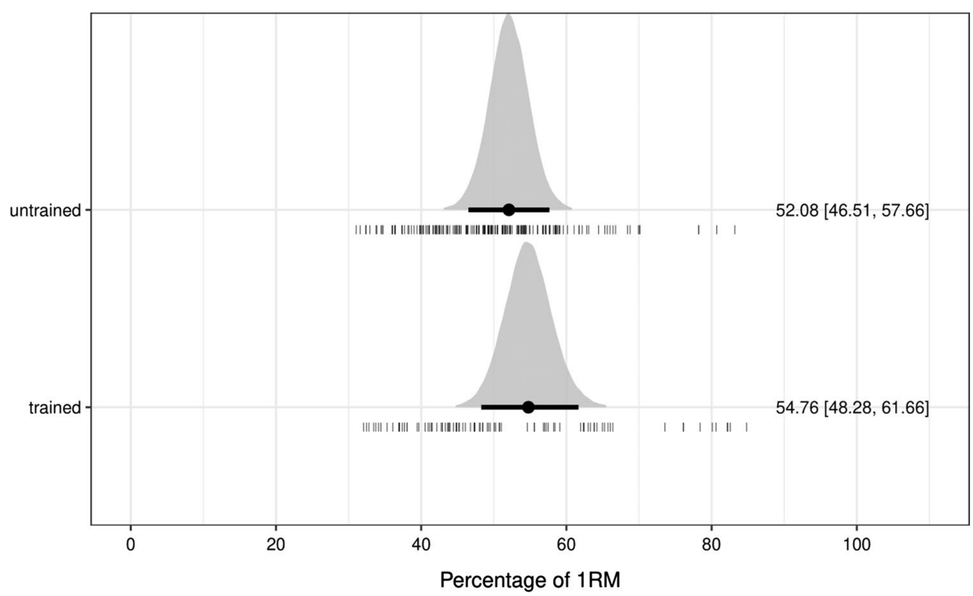

Fig. 3 Training status model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects within each condition

participants reach or approach task failure in sets, hypertrophic adaptations are similar irrespective of the loads lifted [41, 51, 56], although improvements in maximal strength (as measured with 1RM) are superior when using heavier loads [41, 56, 57]. Yet, in 12 of the 18 analyzed studies, participants were required to complete 8–15 repetitions per set, rather than take the sets to task failure. The relatively low average selected load coupled with this repetition range (8–15) suggests that, with the exception of novices [17], study participants trained with insufficient intensity of effort.

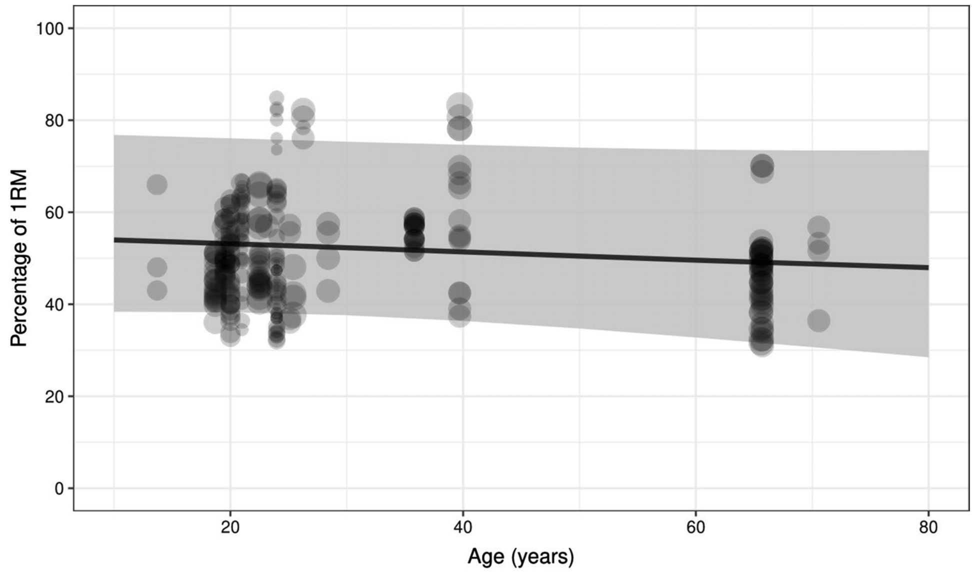

Fig. 4 Age model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance

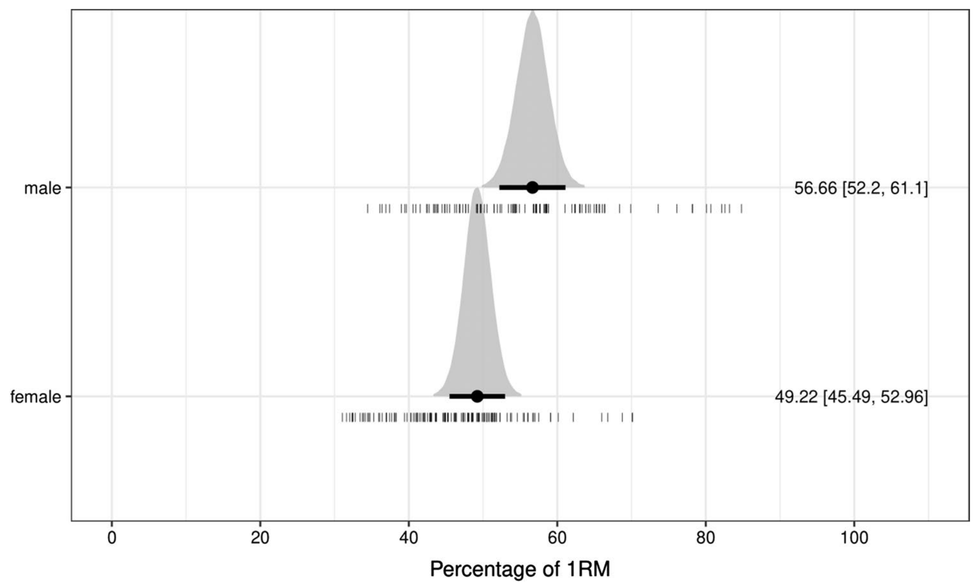

Fig. 5 Sex model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects within each condition

These findings are consistent with two recent studies [5, 54] and our supplementary analyses,[4] showing that participants likely trained at submaximal intensities of effort (based on selected loads coupled with the low number of selected repetitions). However, the instructions regarding the load selection and the limited number of self-selected load sessions in the analyzed studies can partially explain the relatively low loads that trainees selected.

The provided instruction in most of the included studies tended to be vague. For example, trainees were asked to "select a resistance intensity that provided a "good workout" for each exercise" [11], "a load that would be comfortable, yet still provide a good challenging workout" [24], or "a workload that you prefer to perform eight repetitions" [48]. The aim of these studies was not to direct participants towards an optimal load they should be lifting, but rather, to a load they would naturally select without much guidance.

[4] We conducted an exploratory analysis for the three studies that permitted self-selection of loads *and* repetitions. We extracted the selected repetitions at the selected relative loads and compared them to studies that reported the number of repetitions performed to task-failure at different relative loads (i.e., studies from the authors' labs, recent systematic reviews, etc.). Compared to the relevant literature, participants in the three studies typically selected to perform far fewer repetitions than those likely required to reach task-failure at the selected loads, particularly with lower selected loads (for details see analysis code *"### How many repetitions do people do at the loads they select when allowed to choose the repetitions?"* [https://osf.io/54sq7/], additional data [https://osf.io/td26u/], and supplementary output *"# Self-selected vs failure repetitions model"* [https://osf.io/yvud4/] and figure [https://osf.io/xqz9a/]).

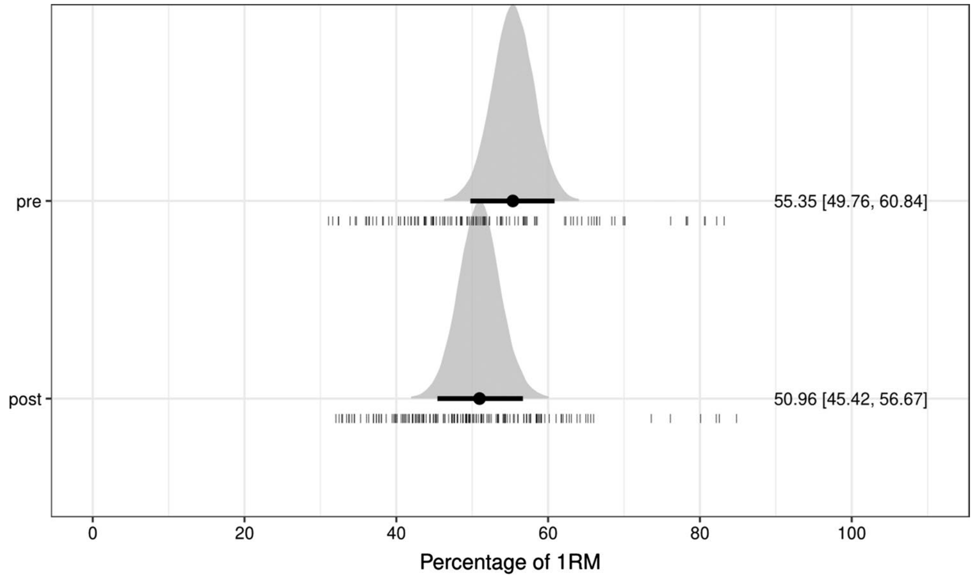

Fig. 6 Timing of 1RM model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects within each condition

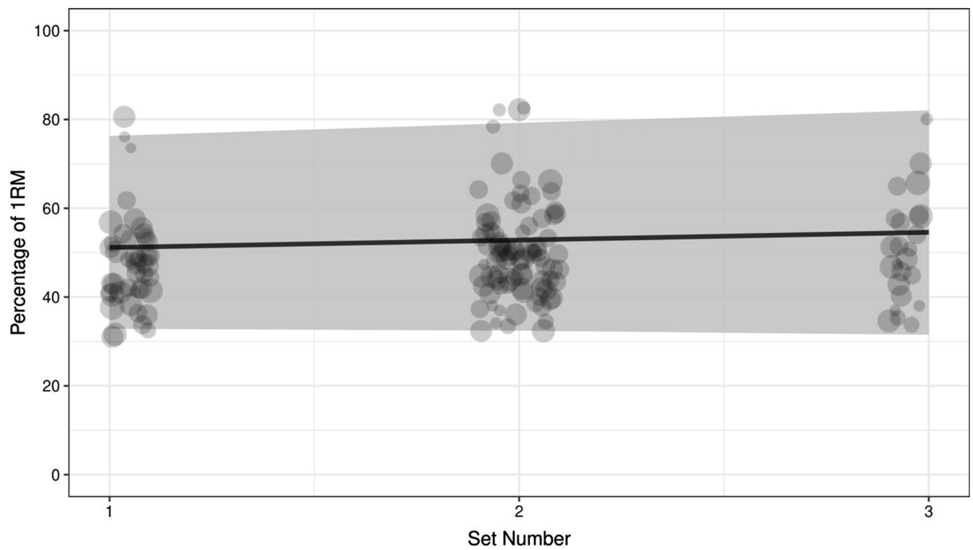

Fig. 7 Set number model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance. A slight horizontal jitter for each point about each integer on the *x*-axis has been applied

Yet, under normal circumstances, trainees receive clearer instructions and guidance as to the loads they should lift (depending on their specific training goals), which should assist them in selecting appropriate loads. We presume that the relatively low selected loads found in this meta-analysis can be partially explained by the instructions provided. Indeed, in the handful of studies that provided clearer load selection instructions, participants tended to select heavier loads and were able to discern between loads under different training conditions [16, 63].

Tiggermann et al. [63], although not included in our meta-analysis due to unavailability of data, had participants select loads for four exercises using a Borg 6 ("no effort")—20 ("maximal effort") rating of perceived effort (RPE) scale over a 12-week period. Every 2 weeks participants were to match a specific RPE score with a selected corresponding load. When required to select loads for sets composed of 12–15 repetitions leading to 13RPE and 16RPE, participants selected loads corresponding to ~ 46%1RM and ~ 69%1RM, respectively, across exercises. Elsangedy et al. [16] had participants select loads for five exercises that corresponded to specific ratings in the Feeling Scale, in which − 5 represents feeling very bad, 0 represents feeling neutral, and 5 represents feeling very good. At ratings of 5, 1, and − 1 trainees selected loads that corresponded to ~ 40%1RM, ~ 67% and ~ 80%1RM, respectively, across exercises. Note that given the variation in instructions, and the difficulty to categorize and code this variable, we did not explore instructions as a possible moderator in our meta-analyses. Hence, the overall results of this meta-analysis should be interpreted with this possible bias in mind. While more research is required to ascertain the influence of different instructions

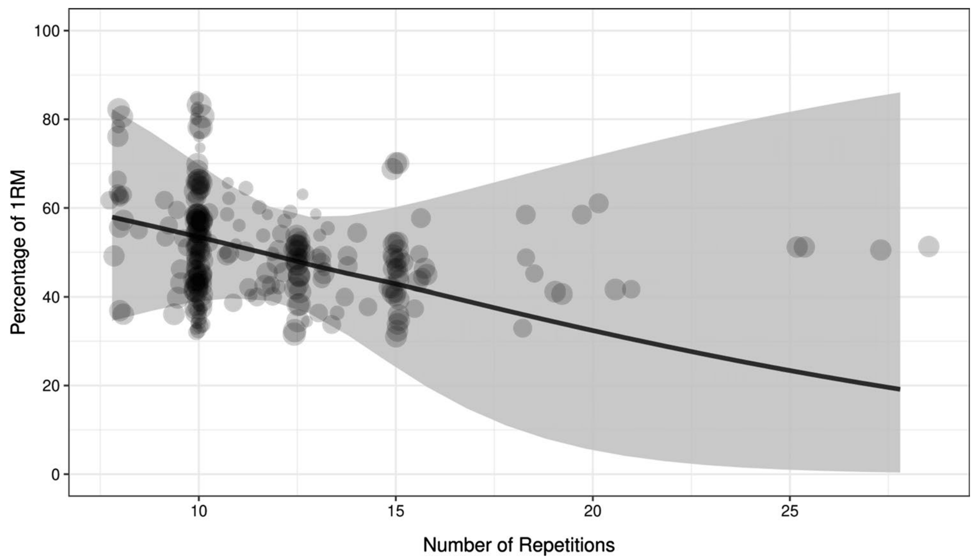

Fig. 8 Number of repetitions model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance. A slight horizontal jitter for each point about each integer on the *x*-axis has been applied

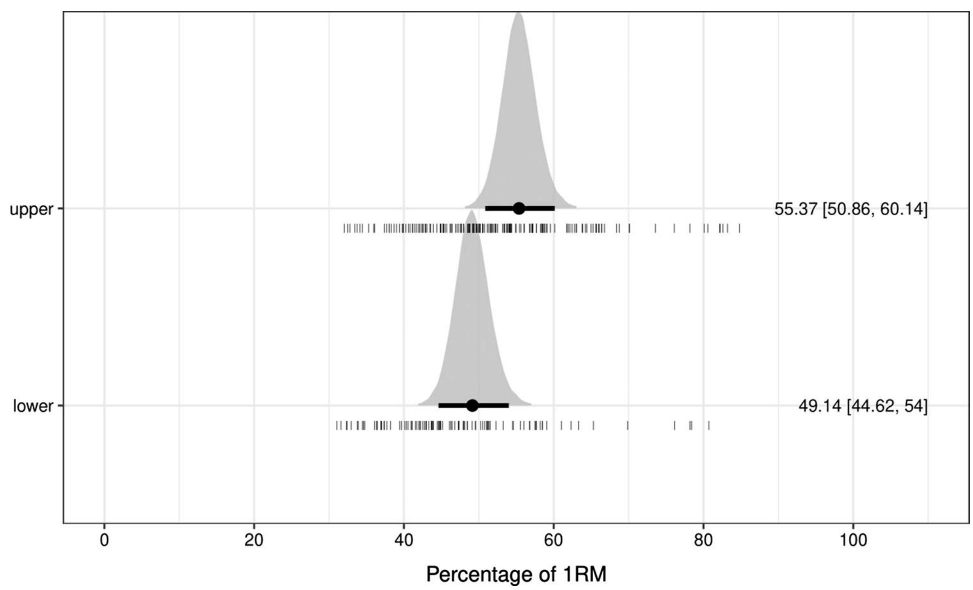

Fig. 9 Upper and lower body exercises model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects within each condition

on load selection, clear instructions and guidance seem important to assist trainees to select loads that are relevant to their goals. This can be accomplished by guiding trainees to select loads using single item-scales such as RPE [34], the Feeling scale [16], and Repetition in Reserve [30].

In most studies, participants completed a single session of self-selected loads. It is possible that within a single session, participants are more hesitant and select lighter loads that would gradually increase in subsequent sessions. This possibility is especially likely with novice trainees, and if trainees are unfamiliar with the exercises. We descriptively observed that the selected loads increased with intervention duration (see https://osf.io/q72ax/), although this was primarily the case in studies where the prescribed number of repetitions was lower, and participants were resistance trained [34]. Therefore, a limitation of our analysis is that we only inspected the loads lifted in a single session or over a small number of sessions. It remains to be established if, and to what extent, participants increase the self-selected loads over time. An answer to this question will shed light on the usefulness of the self-selected load approach.

The self-selecting load prescription approach has weaknesses and strengths worthy of discussion. In order to trigger hypertrophy and increase maximal strength independent of the lifted loads, trainees are required to exercise with sufficient intensity of effort [45, 56]. However, compared to heavier loads, reaching sufficient intensity of effort with lighter loads, such as those selected in the analyzed studies, requires one to complete more repetitions. Sets composed of higher repetition numbers typically lead to greater levels of discomfort [22, 60], pain [18], and cardiovascular strain [18, 64]. Such byproducts may hinder trainees' motivation to exercise over time or to exercise with sufficient intensity (see footnote [d]). Additionally, using the self-selecting load approach can simplify the load prescription process by removing the need for periodic 1RM tests and calculating certain percentages of 1RM. The ability to make choices can increase positive affective responses [23, 62] and improve motor performance [10, 33, 43], although not in a consistent manner [8, 50, 68]. The few longitudinal studies that implemented self-selection load strategies have reported positive outcomes among both untrained [17, 63] and trained participants [30, 35]. Another possible benefit of the self-selected load approach is that exercising according to one's preferences tends to increase adherence rates [19, 32]. While most of the longitudinal self-selected load studies reported medium to high adherence rates (69–100%) [7, 17, 30, 34, 37, 63], one study reported very low rates (5%) [20]. The different study designs, primary outcomes, and populations, makes it difficult to compare and contrast these adherence rates. Collectively, the self-selected load approach has clear advantages and disadvantages. Thought and additional research are required with regard to how, when, and with whom, this approach should be implemented.

5 Conclusion

We found that on average, participants self-select loads that are equal to 53%1RM. Assuming that trainees are approaching or taking sets to task failure, then such loads can be appropriate to stimulate hypertrophy, but less so for increasing maximal strength, regardless of trainees RT experience. We note that a possible byproduct of using lighter loads to task failure is that considerably more repetitions will be required to achieve sufficient intensity of effort. This, in turn, may lead to greater levels of discomfort, pain, and cardiovascular strain, which could negatively affect one's motivation to exercise at a sought-after intensity. In cases where the number of repetitions is fixed at a medium range (e.g., 8–15), which was the case in most of the examined studies, then such loads can be considered sufficient for novice trainees, but not for trainees beyond the novice stage. Using the self-selected approach is simpler to implement, can bypass the requirements for routine 1RM tests, and accounts for trainees' preferences. Thus, it is important to weigh the strengths and weaknesses of the self-selected load approach prior to implementation. Future research is required to ascertain the impact of different types of instructions on load selection and if trainees select heavier loads and exercise with sufficient intensity when following this approach over time.

Declarations

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Conflict of interest The authors declare that they had no conflicts of interest.

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Author contributions IH and JS wrote the first draft of the manuscript. TM, IHN, PAK and MW performed the literature search. JS performed the meta-analyses. All authors were involved in the interpretation of the meta-analyses, read, revised, and approved the final manuscript.

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