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Are we 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 lifted once (i.e., 1 Repetitions Maximum [1RM]). An alternative approach is to allow trainees to self-select 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 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 PhD thesis; 2) had 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 359 participants. **Results:** Our main model indicated that on average participants select loads equal to 53% of their 1RM (95% Credible Interval [CI]: 49% to 58%). There was little moderating effect of 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 vs. upper body exercises. Participants did tend to select heavier loads when prescribed lower repetitions, and vice versa ($logit(y_i)$ = -0.12 [95%CI: -0.21 to -0.04]). **Conclusions:** Participants selected loads equal to an average of 53% of 1RM across exercises. Such loads are suitable for hypertrophic gains assuming that trainees approach or reach the point of task-failure, but may be too light for optimal strength development (as measured with 1RM). The self-selected loads prescribing approach shows promise given that it bypasses certain limitations of the traditional load prescription approach, but requires thought and further research regarding how and with whom it should be implemented.

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Introduction

Load prescription for different resistance 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) [3,33,46]. Trainees are required to complete periodic 1RM tests, or prediction tests of 1RM, 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 60-70% of 1RM in their RT sessions for strength improvements [3,33]. 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 [28], they are time consuming, can require monitoring and assistance, and may be intimidating for the inexperienced [40]. Moreover, 1RM results are influenced by different variables, such as the type of warmup [1], the number of observers [45], feedback and instructions [49]. Imprecise 1RM results can bias the percentage of 1RM used for the training program, leading trainees to follow a different program than intended.

Under the traditional approach, loads are commonly prescribed from a narrow range of 1RM (e.g., 70-85% 1RM) without explicitly considering trainee's load preferences [3,33]. Yet, some trainees may prefer to use relatively heavier loads coupled with fewer repetitions, whereas others may prefer the opposite. Allowing trainees to select their preferred loads is a sensible strategy given that using a range of loads can improve a range of outcomes, even with loads lighter than 60% of 1RM [15,18,39,47]. Choice provision can also elicit positive affective responses [20,51,52] and improve motor performance to compared to a no-choice condition or group (but see [6,44,58] for similar outcomes between choice and no-choice condition or group). Examples of choice provision include allowing trainees to select the repetition range (10, 15, or 20 repetitions) [37], the order of weekly RT sessions [6] and the exercise to be performed [44]. In such studies, we interpret comparable results as favorable towards the choice condition, as the RT program is simpler to plan and implement. Collectively, allowing trainees to select their preferred load can positively affect psychological and performance outcomes and can negate the need to prescribe load based on 1RM. However, prior to advocating alternative load prescription strategies, it is important to develop a clear understanding of what range of loads trainees select to lift.

A growing number of studies have examined what loads participants select in resistance exercises [9,12,14,25]. However, these studies included participants of different ages, sex, and training experiences. 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 is to investigate what loads trainees 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 vs. upper body exercises.

Methods

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 until 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 PhD 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 was considered in the present paper[1]. Two reviewers (TM and IHN) assessed relevant records, and downloaded them into Sciwheel.com (Sciwheel Limited, London, UK). To enable concurrent screening of titles and abstracts by the reviewers, potential records were we uploaded to Abstrackr [56]. 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.

[1] For those chronic studies (i.e., training interventions) where we could obtain the data, we include 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 this 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 smooths 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/).

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 looking to extract was self-selected loads as a percentage of 1RM, whether we could obtain this clearly or calculate it from the absolute 1RM and absolute self-selected loads. The data were extracted for all groups (separated by sex where possible) and conditions, across all exercises, sets, and sessions, within each study[2]. There were thus 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 case the authors did not reply within two weeks. If we were unable to obtain data in this fashion, then we 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).

Meta-analysis

All analysis code utilized is presented in the supplementary materials (https://osf.io/54sq7/). Given the aim of this research, we opted to take an estimation-based approach [23], based within a Bayesian framework [34]. For 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 [38]. The main exploratory meta-analysis was performed using the 'brms' package [5] with posterior draws taken using 'tidybayes' [32] and 'emmeans', and supplementary analyses conducted using the 'metafor' package in R (v 4.0.2; R Core Team, https://www.r-project.org/) [55]. All data visualizations were made using 'ggplot2' [59], and 'patchwork'[41].

Given 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

[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 chronic data included in the supplementary materials.

regression [11,35,57]. Ultimately, we opted to use the beta regression given it overcomes many problems with traditional approaches and transformations, though 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/).

Because of the nested structure of the effect sizes calculated from the studies included (i.e., studies often had multiple groups/conditions and reported effects within these for multiple sessions/exercises/sets), multilevel mixed-effects meta-analyses with both study and intra-study groups (i.e., where there were multiple groups within a given study) were included as random effects in the model were performed. 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 (proportion of sample that were male), timing of the 1RM test, number of sets, number of repetitions, and lower vs. 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 warmup 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 (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.

Results

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

[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).

further studies that met the inclusion criteria. From the chronic studies we could only obtain data of the first sessions from five of them [14,15,17,30,31]. Thus, the final number of studies included in analyses was 18 [2,7,9,10,12–15,17,20,21,24–26,30,31,42,43]. Details of the search and inclusion process are shown in the PRISMA flow chart (Figure 1). Details of the studies can be viewed in Table 1. The pooled number of participants was 359 across 26 participant groups with sample sizes ranging from 2 to 28 participants (median = 13) per group within each study[4]. Full details of all included studies can be seen in the data extraction file (https://osf.io/9bqaz/).

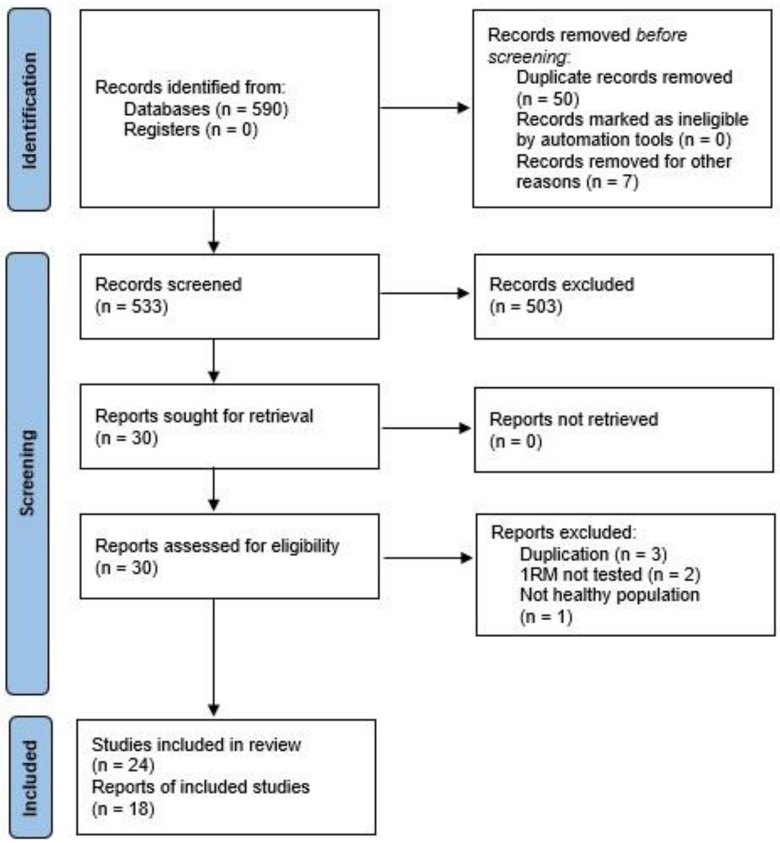

Figure 1. PRISMA flow chart illustrating different phases of the search and study selection.

[4] Data for six chronic studies, including 114 participants across 10 groups had sample sizes ranging from 10 to 28 participants (median = 12.5), were available for the aforementioned supplementary visualisations for chronic effects (see https://osf.io/q72ax/).

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

Article	Participants	Study design	Instructions	Sets and repetitions	Exercises
Alves, 2014	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?"	3x10	Bench press Leg press Biceps curls
Dias, 2017	With personal trainer: 8M/F Age: 24±3 Exp: >1 year W/out personal trainer: 13M/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)."	3x10	Leg press Bench press Knee extension Biceps curls
Dias, 2018	38M/F Age: 23±3 Exp: >6 months	Day 1: SS loads Days 2: 1RM	"Participants were instructed to select a resistance intensity that provided a "good workout" for each exercise type."	3x10	Leg press Bench press Knee extension Arm curl
Elsangedy, 2013	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*)."	3x10-15	Bench press Leg press Lat pull down Leg extension Shoulder raise Knee curl Biceps curl Triceps extension
Elsangedy, 2016	12M 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 3x10 repetitions."	3x10	Bench press Leg press Seated row Knee extension Shoulder press Biceps curl Triceps extension
Elsangedy, 2018	16M Age: 40±7 Exp: novice	Days 1-3: familiarization Days 4-5: 1RM	"Please, select a load associated with a [verbal descriptor of the Feeling Scale randomly selected for that day] feeling,	3x10	Leg press Chest press Knee extension Biceps curl

		Days 6 and onward: 16 RT sessions	corresponding to [numeral descriptor of the FS randomly selected for that day] on this scale for performing 3x10 on the [name of the exercise].”		
Elsangedy, 2020	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 3x15. 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.”	3x15	Bench press Leg press Pull down Knee extension Lateral raise Knee curl Biceps curl Triceps extension
Faries, 2016	46F 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 x SS number of repetitions	Bench press Shoulder press Triceps extension Lat pulldown Biceps curl Leg press
Focht, 2007	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.”	3x10	Knee extension Bench press Lat pull down Shoulder press
Focht, 2015	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.”	3x10	Knee extension Bench press Knee curl Lat pull down
Glass, 2004	30M/F Age: 19±1 Exp: novice	Day 1: familiarization Day 2-3: SS loads Day 4: 1RM	"Choose a load that you feel sufficient to improve your muscular strength."	2 x SS number of repetitions	Bench press Knee extension Row Shoulder press Biceps curl

Glass, 2008	Control: 8M/F Age: 21±2 Exp: novice Experimental: 8M/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 x SS number of repetitions	Bench press Leg press Lat pull down Triceps extension Biceps curl Shoulder press
Glass, 2020	SS group: 10M/F Age: 20±1 Imposed group: 10M/F Age: 20±1	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 x SS number of repetitions	Bench press Leg press Shoulder press Biceps curl Triceps extension Pec fly Knee extension Lateral raise
Helms, 2018	10M 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..."	2-3x2-8 Every 2 weeks the repetitions number decreased and load increased.	Back squat Bench press
Helms, 2017	3F/9M 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: 1-2x8	Back squat Bench press Deadlift

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				1-2x2 1-2x3	
Ratamess, 2008	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?"	1x10	Bench press Leg press Seated row Leg extension
Portugal, 2015	16M 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."	3x8	Pull down Knee extension Bench press Knee curl
VH de O Segundo, 2016	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."	3x10	Bench press Knee extension Lat pull down Knee flexion

Exp: Experience; **RM:** Repetition Maximum; **SS:** Self-selected; **RT:** Resistance Training; **RPE:** Rate of perceived effort.

Main model – All effects

The main model including all effects (283 across 26 groups and 18 studies) suggests that participants, on average, selected a load equal to 53% [95%CI: 49% to 58%]. 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.

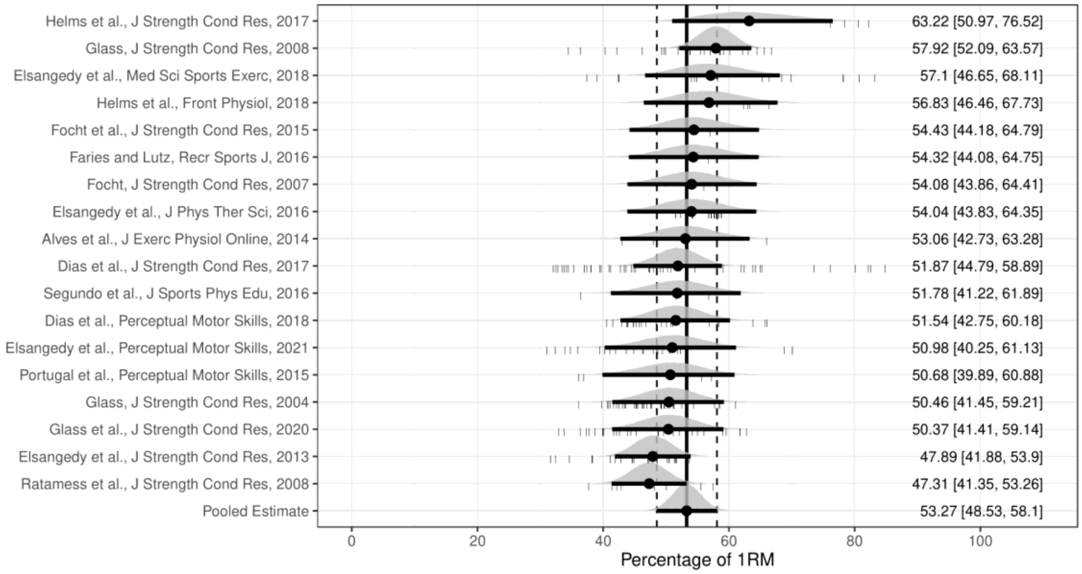

Figure 2. Main model of all effects. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. The thick and dashed lines are the mean and compatibility intervals for the pooled estimate. Ticks below are the individual point estimates for effects within each study.

Meta-regression analyses

Training status

Point and interval estimates were 53% [95%CI: 46% to 59%] and 54% [95%CI: 47% to 62%] for both untrained and trained participants respectively (See Figure 3).

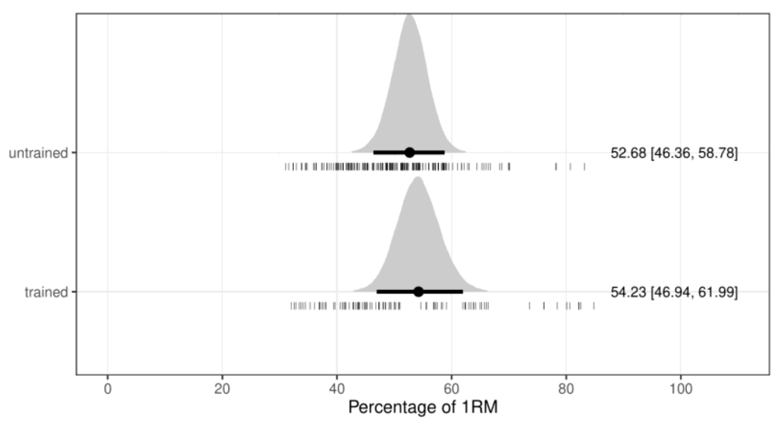

Figure 3. Training status model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects within each condition.

Age

Age had a small impact on load selected with a slope of *logit*(y_i) ≈ 0.00 [95%CI: -0.01 to 0.01] (See Figure 4).

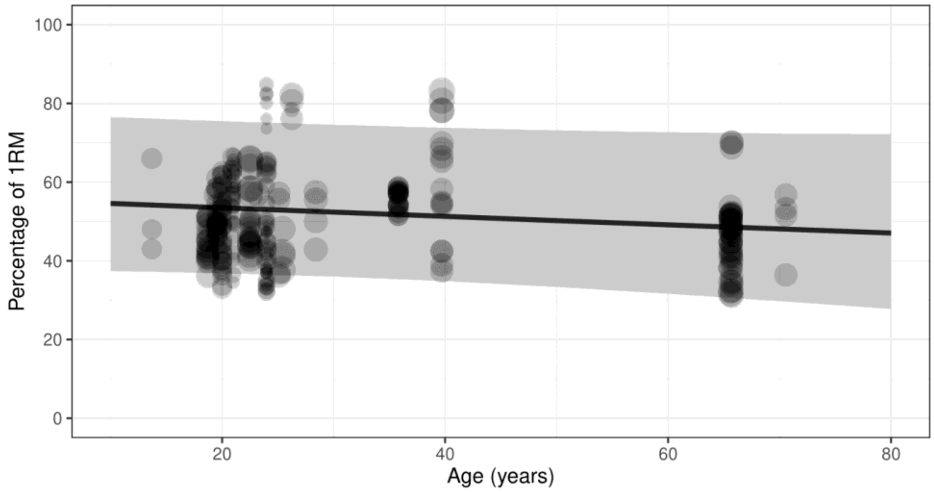

Figure 4. Age model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance.

Sex

Sex had a small impact on load selected with a slope of *logit*(y_i) ≈ 0.00 [95%CI: 0.00 to 0.01] (See Figure 5).

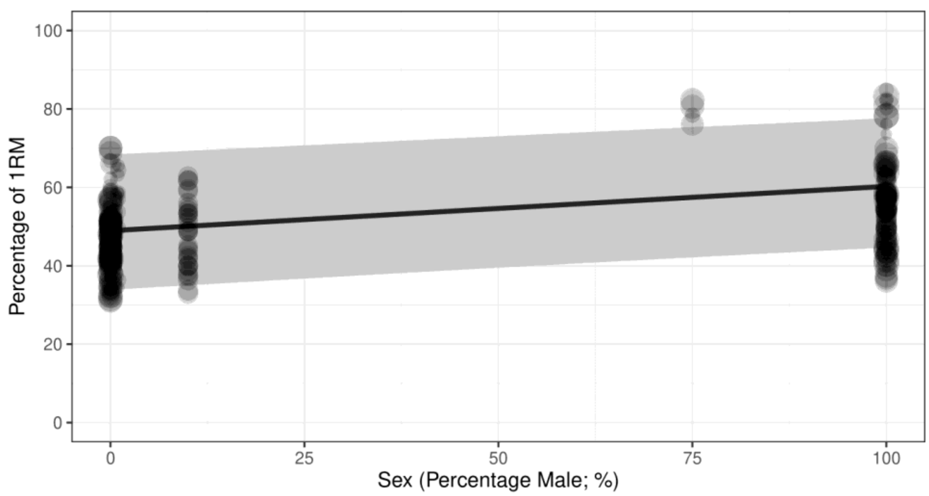

Figure 5. Sex model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance.

Timing of 1RM

Point and interval estimates were 54% [95%CI: 49% to 60%] and 52% [95%CI: 46% to 58%] for both studies where the 1RM tests were completed before, and after, the load selection session, respectively (See Figure 6).

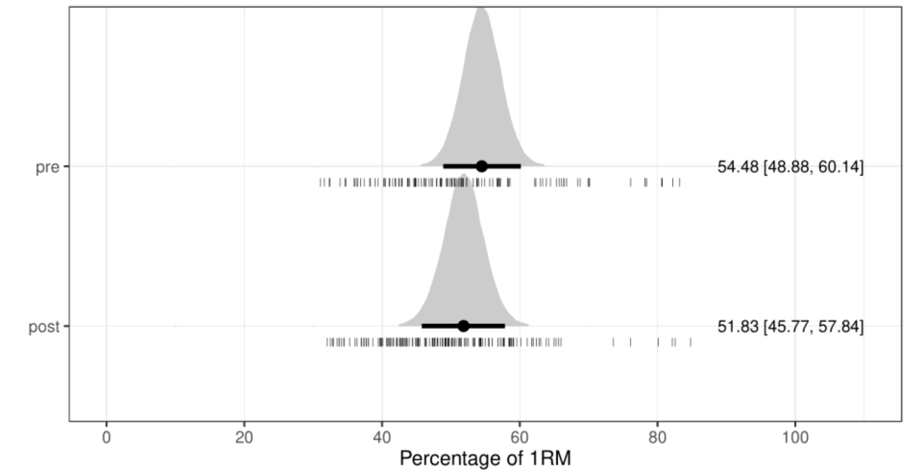

Figure 6. Timing of 1RM model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects within each condition.

3.3.4 Set number

Set number had a small impact on load selected with a slope of *logit*(y_i) = 0.07 [95%CI: 0.02 to 0.12] (See Figure 7).

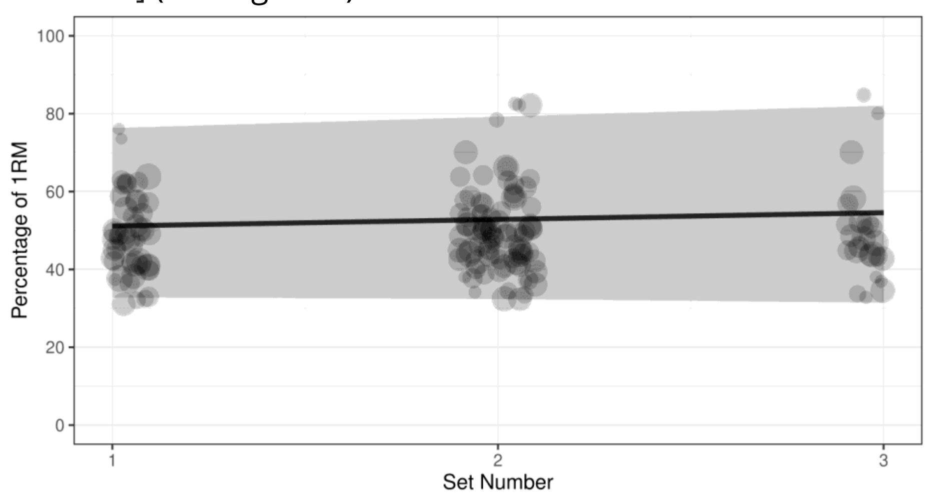

Figure 7. Set number model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance. Note, a slight horizontal jitter for each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

Number of repetitions

Number of repetitions had an impact on load selected with a slope of *logit*(y_i) = -0.12 [95%CI: -0.21 to -0.04] though, due to fewer effects at higher repetition numbers, interval estimates were imprecise at higher values (i.e., >15 repetitions; See Figure 8).

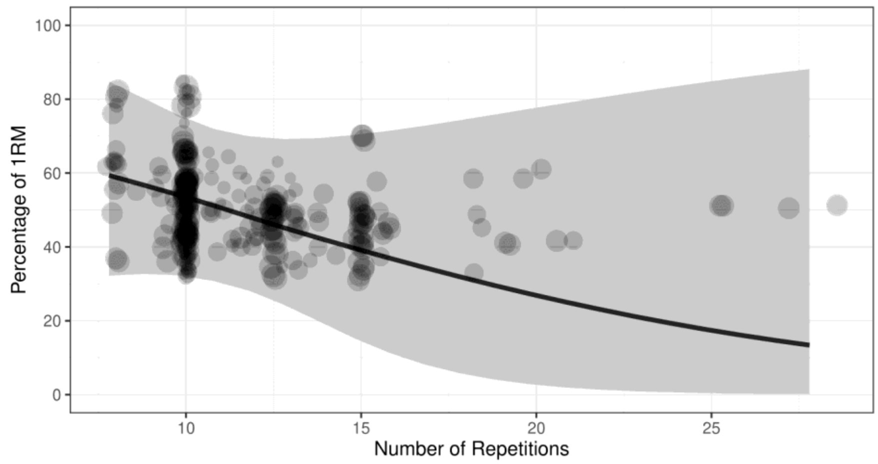

Figure 8. Number of repetitions model. Point and interval estimates (line and ribbon on plot) are mean and compatibility intervals for the posterior probability distributions. Points are the individual point estimates for effects scaled for size by their inverse variance. Note, a slight horizontal jitter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

3.3.6 Upper and lower body exercises

Point and interval estimates were 55% [95%CI: 50% to 61%] and 49% [95%CI: 44% to 55%] for both upper and lower body exercises respectively (See Figure 9).

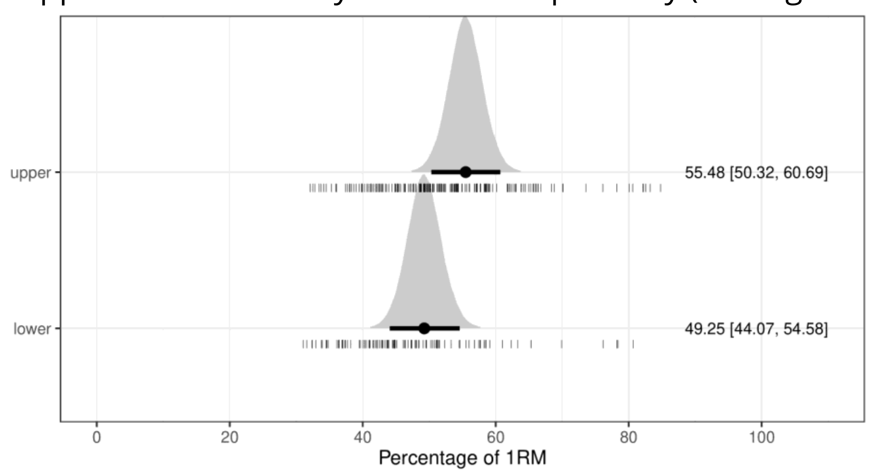

Figure 9. Upper and lower body exercises model. Point and interval estimates (dots and lines on plot, and text on right hand side) are mean and compatibility intervals for the posterior probability distributions depicted by the grey densities. Ticks below are the individual point estimates for effects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

Discussion

In this scoping review and meta-analysis, we explored what loads participants 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 either training experience, age, sex, whether the 1RM test was performed before or after 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.

In a number of the analyzed studies, the authors concluded that participants selected loads that are too light to evoke strength and hypertrophy changes. This conclusion is mostly based on the recommendation by the ACSM, advocating loads of ≥60% of 1RM [22,33]. However, considering load independent of the number of repetitions and proximity to task failure provides a partial indication of training adaptations [18,36,39,47]. Indeed, as participants reach or approach task-failure in a given set, hypertrophic adaptations are similar between groups irrespective of the lifted loads [48]. Strength improvements (indicated by increases in 1RM), are commonly larger when training with heavier loads, but this could also be a case of practicing the test [4,36]. Regardless, strength meaningfully improves when using lighter loads, even if to a lesser extent [15,18,39,47]. Future studies inspecting load selection should account for the number of repetitions, and ideally, proximity to task-failure, when interpreting the results. This can be done by having participants self-select loads, the number of repetitions (as was done by three studies in the analysis [24–26][5]), and by including several sets to task-failure completed in proximity to the self-selected sets. This would allow estimating the proximity to task failure in the self-selected sets and provide a better indication of the degree of effort put forth in a given set.

In most of the analyzed studies, participants were required to complete 10 repetitions per set. In view of this repetition number, it may be sensible to conclude that the average selected load (~53% of 1RM) was too light to gain hypertrophy or maximal strength for experienced trainees, but may be suitable for novice trainees. In support of this assumption, Elsangedy et al [15] had older adults inexperienced in RT follow a self-selected load RT program for 12 weeks. The selected loads in all exercises were around 50% of baseline 1RM throughout the period. Despite this, considerable improvements were observed in trainees' maximal

[5] We conducted an exploratory analysis for these three studies. We extracted the selected repetitions at the selected relative loads and compared it to a number of studies that reported the number of repetitions performed to task-failure at different relative loads (i.e., studies from the author's labs, recent systematic reviews, etc.). Compared to the relevant literature, participants in the three studies typically selected to perform far fewer repetitions than those required to reach failure, particularly with the 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/])

strength, body composition, and functional outcomes. Moreover, in most of the acute 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. Indeed, 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 [30].

The provided instruction in most of the analyzed studies tended to be vague. For example, trainees were asked to *"select a resistance intensity that provided a "good workout" for each exercise"* [9], *"a load that would be comfortable, yet still provide a good challenging workout"* [21], or *"a workload that you prefer to perform eight repetitions"* [42]. The aim of these studies was not to direct participants towards a proper load they should be lifting, but rather, to a load they would naturally select without too much guidance. Yet, under normal circumstances, trainees receive clearer instructions and guidance as to the loads they should lift, which should assist them in selecting appropriate loads. We presume that the relatively lower selected loads found in this meta-analysis can be partly explained by the provided instructions. 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 conditions [14,53].

Tiggermann et al. [53], though 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 two 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. [14] 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 inspect the influence of different instructions on load selection, clear instructions and guidance seem important to assist trainees select loads that are relevant for their goals.

The self-selecting load prescribing approach has weaknesses and strengths worthy of discussion. In order to optimize gains in hypertrophy and maximal strength independent of

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the lifted loads, it seems as if sufficient intensity of effort is required (i.e., approaching or reaching the point of task failure) [39,48]. However, compared to heavier loads, reaching sufficient intensity of effort with lighter loads requires one to complete more repetitions, which leads to greater levels of discomfort [19,50], pain [16], and cardiovascular strain [16,54]. Such byproducts may hinder trainee's motivation to exercise with sufficient intensity (see footnote *e*). Even if the selected loads increase over successive sessions, it may be more difficult to plan training programs, and to keep track of long-term progress. Conversely, 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 [20,52] and improve motor performance [8,29,37], although not in a consistent manner [6,44,58]. The few longitudinal studies that implemented self-selection load strategies reported positive outcomes among both untrained [14,53] and trained participants [27,31]. Collectively, the self-selected load approach shows promise, but requires thought and research regarding how, when, and with whom, it should be implemented.

In conclusion, we found that participants self-select loads that are equal to 53%1RM, on average. The selected loads may be appropriate for some, but not all levels of trainees, and may depend on the number of repetitions performed. We note that a possible byproduct of using lighter loads with the goal of increasing hypertrophy and maximal strength is that 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 ones motivation to exercise at a sought after intensity. Hence, prior to implementing the self-selected load approach, it is important to weigh its strengths and weaknesses. Future research is needed to inspect other aspects of the self-selected approach including the combination of self-selected load and repetitions, and the impact of exposure to this training method over time upon the selected loads.

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Data and Supplementary Material Accessibility

All materials, data, and code are available on the Open Science Framework project page for this study https://osf.io/8qpgs/

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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