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Short-term supervised virtual training maintains intensity of effort and represents an efficacious alternative to traditional studio-based supervised strength training

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ABSTRACT

Background: Virtual personal training might represent an uncomplicated, accessible, and time-efficient approach to supervised strength training, particularly under government-imposed lockdown or closure of fitness facilities. However, there appears a dearth of literature evaluating the efficacy of virtual personal training.

Methods: The present study considered trained participants being supervised one-to-one through traditional resistance exercise sessions in a strength training studio (STUD), compared to a virtual personal training protocol performed using bodyweight resistance exercises (VIRT). The study utilized a crossover design whereby male (*n*=13) and female (*n*=7) participants were tested for body composition using BodPod, and strength for bench press, leg press, and high-row exercises. Participants were then randomly assigned to 3-weeks of VIRT or 3-weeks of STUD training. Following each 3-week training period, participants had a 1-week washout period without training whereby mid-intervention testing occurred, after which participants then completed the alternate training intervention. Further, we surveyed the client base of a chain of training facilities who had begun offering virtual personal training during lockdown to explore their views on this approach.

Results: Strength and body composition changes were similar between groups, however for neither condition did results surpass the smallest meaningful change. The remaining survey data suggests that supervised virtual resistance training yields similar perceptions of effort, motivation, enjoyment, and supervision quality, compared to traditional supervised studio training.

Conclusion: Based on the current data, it appears that short-term supervised virtual resistance training is as efficacious as traditional supervised studio-based resistance training.

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Keywords: Strength, Body composition, bodyweight strength training, resistance training, perceptual responses, supervision

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Introduction

Low-volume, high-effort resistance training can be an efficacious and time-efficient approach to increasing muscular size and strength (Giessing, et al. 2016; Schoenfeld, et al. 2019; Cunha, et al. 2020). Furthermore, these are independently strong predictors of longevity and quality of life (Ruiz, et al. 2008; Srikanthan, et al. 2014). However, most published research considering strength training has utilized *supervised* resistance training to deliver the exercise protocol and promote adherence and progression. Authors have suggested that a lack of supervision within strength training can result in inadequate workout quality and diminished results (Hillman & Pearson, 1995). Indeed, Kraemer, et al. (2002) stated that *"the key element to effective resistance training is supervision by a qualified professional…"*. Supervision within resistance training might be of importance for several reasons: (i). the promotion and accurate monitoring of adherence (attendance) and maintenance/continuation (Coutts, et al. 2004), (ii). the accurate monitoring and progression of strength training protocols including load progression (Mazzetti, et al. 2000; Ratamess, et al. 2008; Dias, et al. 2017) (iii). the inclusion of technical coaching, which might serve to prevent injury and more effectively target specific muscles by preventing "cheating" (Coutts, et al. 2004), (iv). the provision of encouragement and psychological support, which might enhance the positive experience of resistance exercise, and (v). encouragement that might augment intensity of effort (Coutts, et al. 2004; Ratamess, et al. 2008; Dias, et al. 2017). Indeed, a recent meta-analysis suggests that, while small, supervision may have an impact on strength gains produced by resistance training (Fisher et al., 2021).

Since time constraints and perceived difficulty are often cited barriers to engagement/adherence to resistance training (Trost et al., 2002; Winett et al., 2009), it makes sense to potentially *off-load* these decisions and address commitment by engaging in supervised resistance training. Indeed, evidence supports that, for a variety of population groups, supervision might enhance adherence to resistance training (Coutts, et al. 2004; Stefanov, et al. 2013; Dalager, et al. 2015; Rustaden, et al. 2017; Hunter, et al. 2020). However, in some situations it may not be possible to engage in face-to-face supervision, particularly as a result of gym closures as occurred due to the recent Covid-19 lockdown protocols (Steele, et al. 2021). In this situation, many fitness facilities, personal trainers, and strength coaches transitioned to 'virtual' personal training (i.e., providing remote supervision using a virtual platform, e.g., Zoom™, Skype™, MS Teams™, Google Hangout™, etc.). Marcus, et al. (2000) suggested that technology can be *"an ideal medium to effect behavior change"*, suggesting that virtual personal training might not just be for those who are replacing existing supervised sessions but could promote engagement and adherence in muscle-strengthening exercise without the commitments and travel time to specific fitness facilities.

Indeed, *"Online training"* was identified as the top trending phrase by the American College of Sports Medicine (ACSM) in 2021 (Thompson, 2021).

To date, there appears a dearth of literature evaluating the efficacy of virtual personal training. Tallner, et al (2016) compared internet-based personal training using aerobic training (1x/week), and strength training (2x/week) to a non-training control condition in persons with multiple sclerosis. Following 3-months of training, the authors reported significant increases in knee flexion and knee extension muscle strength, peak expiratory flow, and physical activity. A second study considering older adults (69 to 93 years) compared a resistance training intervention to a control group (Hong, et al. 2017). The intervention group performed virtual supervised resistance exercise sessions for 20-40 minutes/day, 3days/week for 12 weeks. The authors reported significant improvements in lower limb muscle mass, total muscle mass, and chair and sit-and-reach length for the virtual training group compared to the non-training control group. There were no between-group differences for a 2-minute step test and chair stand test. Schwartz et al. (2021) recently explored the feasibility of personal training delivered via online video conferencing (Zoom™) in community dwelling older adults, reporting high adherence, few dropouts, no adverse events, and that participants rated the training positively. Finally, Kikuchi, et al. (2021) recruited participants to perform resistance training using bodyweight or resistance bands, comparing a group supervised virtually via Zoom, to a group performing the same resistance training protocol supervised face-to-face. Following 8 weeks of training 2x/week, the data revealed no differences in strength increases, muscle mass increases and decreases in blood pressure and arterial stiffness. However, results for a chair stand and sit-and-reach test were greater for the face-to-face training group.

Considering the popularity of online training (Thompson, 2021) and that over lockdown in particular it was those already active who continued to participate in exercise (Strain et al., 2022) to date, there appears no research considering the efficacy of virtual personal training in trained males and females . Furthermore, whilst evidence has supported that strength and muscle mass adaptations are similar for both heavier- and lighter-loads (Fisher, et al. 2020; Schoenfeld, et al. 2021), virtual personal training often relies on trainees utilising bodyweight exercise or what weights and equipment they may have available at home. During lockdown, despite most people performing resistance training at home, most utilised higher repetition ranges suggesting the use of lighter loads (Steele et al., 2021). While evidence suggests similar outcomes between bodyweight and other resistance modalities (Kikuchi et al., 2017; Kotarksy et al., 2018) only one study has compared virtual and face-to-face training interventions using the same bodyweight and resistance band exercises in both groups (Kikuchi, et al. 2021).

Based on the above, the present study considered strength and body composition changes for trained male and female participants being supervised one-to-one through traditional resistance exercise sessions using free-weights and resistance machines in a strength training studio (STUD), compared to a virtual personal training protocol performed using bodyweight resistance exercises (VIRT). Further, we surveyed the client base of a chain of training facilities who had begun offering virtual personal training during lockdown to explore their views on this approach.

Methods

Experimental Design

The present study considered the efficacy of a short-term (3-week) virtual strength training intervention. The study utilized a crossover design whereby participants were randomly assigned to 3-weeks of either 1-on-1 supervised virtual strength training (VIRT) or 3-weeks of 1-on-1 supervised strength training within a studio (STUD). Following each 3-week training period, participants had a 1-week washout period without training whereby mid-intervention testing occurred, after which participants then completed the alternate training intervention. The total duration of the study was 10-weeks, broken down in the following way: Weeks 1 and 2 were used for pre-intervention body composition and strength testing (see below for details), weeks 3-5 consisted of the first training intervention (i.e. VIRT or STUD), week 6 was mid-intervention strength and body composition testing, weeks 7-9 consisted of the crossover/alternate training intervention (i.e. VIRT or STUD), and week 10 was used for post-intervention body composition and strength testing. In addition, a survey was administered to participants adapted from Steele et al. (2021) with slight alterations to training questions to reflect the population sampled, and the inclusion of questions relating to their participation in, and thoughts regarding, virtual training. Retrospective ethical approval was granted from the first authors' institution.

Participants

Participants for the experimental intervention aspect of this study (see table 1) were recruited from the portfolio of staff (personal trainers, concierge, and administrative) from a chain of strength training facilities (Discover Strength) in Minneapolis, MN, USA, and the surrounding area. This ensured all participants were familiar with high-effort (i.e., training to muscular failure and occasionally the use of advanced training techniques such as drop-sets, pre- or post-exhaustion, forced repetitions, etc.), low-volume (i.e., a single set of each exercise), and twice-weekly training practices, all for a period of mean=3.0 ±2.5 years and randomly assigned into VIRT and STUD groups.

Table 1. Demographic characteristics for intervention participants

Characteristic	N = 20[1]
Sex	
Female	7 (35%)
Male	13 (65%)
Age (years)	28 (27, 30)
Height (cm)	173 (169, 180)
Weight (kg)	80 (68, 87)
Body Fat (%)	18 (16, 22)

[1] n (%); Median (IQR)

For the survey aspect of the study we distributed an invitation to participate in the survey to the existing client base of the same chain of strength training facilities during the lockdown period after virtual training had been implemented for several months already.

One hundred and ninety-three responded, and after cleaning processes (i.e., attention and bot checks, out of range responses etc.) we were left with data from 134 respondents (table 2).

Table 2. Demographic characteristics for survey respondents

Characteristic	N = 134[1]
Age (years)	52 (44, 59)
Sex	
Female	78 (58%)
Male	56 (42%)
BMI (kg.m^2)	25.7 (23.1, 28.9)
Race	
White	129 (96%)
Asian	3 (2.2%)
Mixed	1 (0.7%)
Other	1 (0.7%)
Development	
Urban	25 (19%)
Suburban	105 (78%)
Rural	4 (3.0%)
Yearly Household Income (USD)	250,000 (125,000, 323,750)
Employment	
Employed full time	83 (62%)
Employed part time	6 (4.5%)
Self-employed	22 (16%)
Unemployed	6 (4.5%)
Furloughed	2 (1.5%)
Other	15 (11%)
Working Environment	
No	32 (24%)
Yes (working from usual location)	38 (28%)
Yes (working remotely)	63 (47%)
Yes (currently not working)	1 (0.7%)
Self-Isolation	60 (45%)
Children	50 (37%)
Number of Children	
1	8 (16%)
2	28 (56%)
3	13 (26%)
4	1 (2.0%)
Care Giver	7 (5.2%)
Education	0 (0%)
Resistance Training Experience (years)	7 (4, 13)
Strength Sports	4 (3.0%)
Bodybuilding	1 (0.7%)
Endurance Sports	63 (47%)
Other Sports	79 (59%)

[1] Median (IQR); n (% of total N)

Given the prompt nature of the study being conducted due to the time-sensitivity of the implementation of COVID-19 based lockdown measures including gym-closures our sample sizes for both aspects were convenience-based given the feasibility and accessibility of the desired populations (i.e., previously trained persons, and those who had previously had the opportunity to participate in virtual training). Further, we opted to utilise exploratory and estimation-based analyses and not hypothesis testing procedures (see below).

Testing

Pre-, mid-, and post-intervention muscular performance testing were completed using a 6-8 repetition maximum (RM) from which 1RM was predicted. This was performed (with 120 s of rest between exercises) using a barbell bench press, leg press (Avenger, MedX, Ocala, Fla., USA), and high row (Nautilus, Vancouver, Wash., USA) resistance machines (in that order). These exercises were chosen specifically as impartial exercises for testing since they would not be used for training by either group. Whilst the STUD group would be using resistance machines, they would not be using these specific models. Because all participants were existing staff members at the facility at which testing and training took place, 6-8RM loads were estimated from the pre-existing training load for testing. Participants first performed a warm-up set of 5 controlled repetitions using a load equal to 50% of the estimated 6-8RM load. After 90 s of rest, the participants performed a set of repetitions to momentary failure (MF) using a 2-s concentric, 4-s eccentric repetition duration. If participants exceeded 10 repetitions, they were instructed to stop and not continue to MF. A rest of 5 min was then permitted before adjusting the load and attempting the 6-8RM again. It was not considered essential that an exact 6-8RM load was identified, just a load permitting failure between 6 and 10 repetitions (for both pre-, mid-, and post-intervention testing, this resulted in a mean of ~7 repetitions). This data was then used to predict 1RM using the Brzycki (1993) equation:

$$\text{predicted 1RM} = \text{load lifted} / (1.0278 - [0.0278 \times \text{number of repetitions}])$$

This has been shown to have a very high correlation to actual 1RM ($r = 0.99$; Nascimento et al. 2007). It was considered that this method provided strong ecological validity to realistic training conditions because most people do not test their maximal strength every 3 weeks, and evidence exists that practicing a test can increase maximal strength by neural (skill-based) adaptations (Mattocks, et al. 2017). MF during testing was defined as the point at which, despite the greatest effort, the participant failed to complete the concentric phase of a repetition (Steele et al. 2017). Pre-intervention testing was performed twice within week 1, with at least 72 hours between testing conditions, to assess the reliability of this testing method and establish a baseline. Mid- and post-intervention testing was performed at least 72 h after the final training session for each intervention as per previous research (Fisher et al. 2014, 2016). The instructor performing the testing before and after the intervention was blinded to group assignment. Predicted 1RM was considered for each exercise, in addition to a combined strength total calculated as the sum of the predicted 1RM from each exercise.

Body composition was estimated using both air displacement plethysmography (Bod Pod GS, Cosmed, Chicago, Ill., USA) and anthropometric measures. Details of the test procedures for estimating body composition using air displacement plethysmography have been described in detail elsewhere (Dempster and Aitkens 1995). Briefly, while wearing minimal clothing (a swimsuit or tight-fitting underwear) and a swim cap, participants were weighed using a calibrated digital scale. Each participant was then seated in the Bod Pod for body volume measurement. From the body mass and body volume measurements and predicted thoracic lung volumes, body density was estimated by the Bod Pod software, and lean and fat mass estimations were calculated using the Siri equation.

Training Intervention

Resistance training was performed 2 days/week (with at least 48 h between sessions) for 3 weeks for both VIRT and STUD training. For STUD training, participants completed two workouts (A and B) for exercises included in Table 3 for a single set. All exercises were performed using Nautilus Evo or Nautilus 2ST, MedX or MedX Avenger equipment. All training sessions were performed at a 1:1 (trainer/trainee) supervision ratio using a 2s concentric: 4s eccentric repetition duration with a load which elicited concentric muscular failure (as described for testing) in 8-12 repetitions. A 3-week intervention period was used for multiple reasons; firstly – trained persons, such as the participants within this study, might typically only transition to virtual strength training for abbreviated periods – perhaps during travel, or when access to typical fitness facilities is limited (e.g., during Covid-19 lockdown), secondly – when ceasing resistance training for 3 weeks, previously acquired strength and muscle size appear to diminish (Ogasawara, et al. 2013). In that sense, any increases or maintenance of strength and muscle mass might be thought of as favorable.

Table 3. Weekly resistance training program (STUD), workouts A and B, both performed once each week.

Workout A	Workout B
Chest Press	Pec Fly
Pullover	Pulldown
Lateral Raise	Overhead Press
Biceps Curl	Seated Shrug
Leg Press	Leg Press
Adductor	Leg Curl
Abductor	Leg Extension
Seated Calf Press	Tibialis Anterior (Ankle Dorsi flexion)
Abdominal Flexion	Torso Rotation
Lumbar Extension	

For VIRT training, participants were also trained using a 1:1 (trainer/trainee) supervision ratio using *Google Meet*™ for 2 different workouts/week. Exercises were designed to be as rudimentary as possible based on the absence of equipment expected in a lay-persons home whilst trying to replicate what a trainee might typically perform in a studio workout. Many of these exercises utilized timed static contractions (TSC), whereby the persons performed an isometric press or pull providing (close to) maximal effort for a given time (90 seconds). Other exercises were performed using bodyweight, and where dynamic; used the same 2s concentric: 4s eccentric repetition duration used for the STUD workout performed to muscular failure, or where static (i.e., the wall sit); were performed isometrically for maximal time. The exercises for the VIRT workout are detailed in Table 4, and video examples of the exercises are available in the online supplementary materials (https://osf.io/q8d4r/ ; see Materials > Exercise Videos).

Table 4. Weekly resistance training program (VIRT), workouts A and B, both performed once each week.

Workout A	Workout B
Towel lateral raise (TSC; 90secs)	Towel rear deltoid (TSC; 90secs)
BW Push-ups (dynamic)	Pec fly (TSC; 90secs)
Towel seated row (TSC; 90secs)	Chin-up OR Towel Seated Row (TSC; 90secs)
BW dip or chair dip (dynamic)	BW Push-ups (dynamic)
Isometric BW wall sit*	Train track band abduction (60secs)
Adductor (TSC; 90secs)	BW Prom lunge (dynamic)
BW Split Squat (dynamic)	Towel/ball Hamstring Curl (dynamic)
DYN BW single leg calf raise	Isometric BW wall sit*
BW abdominal (dynamic)	Isometric BW Plank*
Towel low back (TSC; 90secs)	BW Superman/Woman – 6 x 20secs (dynamic)

BW = bodyweight, TSC = (isometric) timed static contraction, * = isometric exercises performed for maximal time

Survey

The survey was administered through JISC Online Surveys (Bristol, UK) and a copy of the survey is available in the supplementary materials (https://osf.io/vzrs2/). As noted, we adapted the previous survey reported by Steele et al. (2021) regarding training behaviours both before, and during, lockdown including whether they had purchased specific equipment and how much they had spent, whether training was performed once or twice weekly (the two frequencies usually employed by the clients sampled), their rating of the perception of effort during training, and their current goals for training. We also asked participants regarding their current motivation, and to compare their current training to their training prior to lockdown regarding its perceived effectiveness, enjoyment, the quality of supervision (all clients had trained previously under supervision at the facility) and the likelihood they would continue their current training. We also included additional questions regarding other types of exercise that they engaged in prior to lockdown (in addition to resistance training at Discover Strength facilities), whether they had engaged in virtual training since lockdown and if not what would make them more likely to do so, whether they had engaged in studio based training since lockdown (i.e., during the periods where gyms reopened), and what their current predominant training approach is. Lastly, we included a question aimed at improving our ability to draw inferences regarding the meaningfulness of any changes in strength following other recent examples (e.g., Androulakis-Korakakis et al., 2021); that is to say, we asked participants what they would consider to be the smallest change in strength that could be deemed meaningful.

Statistical analysis

This study was not pre-registered and thus all analyses and results should be considered descriptive and/or exploratory in nature. We opted to take an estimation-based approach (Gardner and Altman, 1986; Cumming, 2013) situated within a Bayesian inferential framework (Kruschke and Liddell, 2018). For all inferential analyses, effect estimates and their precision along with conclusions based upon them, were interpreted continuously and probabilistically, considering data quality, plausibility of effects, and previous literature, all within the context of each outcome (Amrhein et al., 2019; McShane et al., 2019). Inferential statistics from analyses presented here should be treated as highly unstable local descriptions of the relations between our model assumptions and data to acknowledge the inherent uncertainty in drawing generalised inferences from single samples (Amrhein et al., 2019). We adopted the Bayesian approach of determining a "ROPE" (Region of Practical Equivalence) for strength and fat mass as outcomes for the intervention part of the study. For strength, we utilised data from the survey regarding the smallest change in strength that participants would deem to be meaningful. For fat mass, we determined this based upon the ~3% loss of body weight as fat mass suggested to be meaningful in the American College of Sports Medicine Position Stand regarding weight loss (Donnelly et al., 2009). and R Studio (R Studio Team, 2015), and all data and code are available in the supplementary materials (https://osf.io/q8d4r/). 4.1.0; R Core Team, https://www.r-project.org/) and R Studio (R Studio Team, 2015), and all data and code are available in the supplementary materials (https://osf.io/q8d4r/).

For survey data (with the exception of the smallest meaningful change) descriptive statistics are presented (response counts, medians). Alluvial plots were used to depict changes in responses over time (pre- and during lockdown) for resistance training equipment purchasing behaviour and frequency of training. For resistance training goals, we present a raster plot of the 2x2 crosstabulation for pre- and during lockdown responses with colour gradient and also counts numbers for each cell. Rating of perception of effort is visualised with a scatterplot of raw units for pre- and during lockdown in addition to the median responses. Bar plots were used to depict response counts and proportions for current motivation, perceived effectiveness (split by whether goals had or had not changed), enjoyment, the quality of supervision and the likelihood of continuing current training. For the smallest meaningful change in strength, we fit an intercept only zero-one inflated beta model on the percentage changes as proportions (on the interval 0 to 1), and then took draws from the posterior distributions (n = 4000) for the model intercept term in order to determine the mode and 95% highest posterior density intervals (HDI). The mode of this distribution was used as our ROPE in the intervention strength outcomes described below.

For intervention data we calculated the delta (i.e., change scores) between the start and end of each intervention period to use as our dependent variable, with the intervention condition (STUD or VIRT) as the independent variable of interest. We essentially fit a Bayesian mixed effects model with random intercepts by participants as an extension of the typical analysis of covariance (ANCOVA) model used in randomized trials for comparison of interventions, whereby the baseline scores are used as a covariate to adjust for effects such as regression to the mean and to permit greater efficiency and precision of estimates. This model accounted for dependence of observations between individuals across conditions. We then took draws (n = 4000) from the posterior distributions for estimated marginal means for each condition and plotted these along with modes and 95% HDI for visual comparison with the ROPE intervals as noted above for strength and fat mass changes. Where distributions overlapped with the ROPE, we calculated the proportion that was above and below this threshold. Note, given that the ROPE for strength was determined on the percentage scale (as we had different resistance machine based strength outcomes), though the models were fit to the raw units (i.e., the predicted 1RM) we transformed the draws of estimated marginal means to percentages by normalising them to the model intercepts.

Bayesian models were fit with uninformed default priors using four Monte Carlo Markov Chains with 1000 warmup and 1000 sampling iterations, using the “brms” package (Bürkner, 2017; 2018) with posterior draws taken using the “tidybayes” (Kay, 2020) and “emmeans” (Lenth, 2020) packages. All data visualisations were made using “ggplot2” (Wickham, 2009) and “patchwork” (Pedersen, 2019) packages, with alluvial plots (for survey data) made using “ggalluvial” (Brunson and Read, 2020). Within visualisations for Bayesian regression models, we note the model specification in Pinheiro-Bates modified Wilkinson-Rogers notation (Wilkinson and Rogers, 1973; Pinheiro and Bates, 2006) for reference.

Results

Survey Responses

Training practices from pre- and during lockdown are presented in Table 5. In brief, prior to lockdown only a small percentage of participants were engaging in resistance training at another studio (4.5%) or at home (6.7%). However, most people were engaging in some form of cardiovascular exercise (19% at another studio and 69% at home). Since lockdown around 89% of respondents had transitioned to virtual personal training provided by Discover Strength. Furthermore, post-lockdown (e.g. after the reopening of fitness facilities) 13% of respondents were engaged in combined studio and virtual personal training, whilst 15% were engaged in virtual only, and 72% in studio only.

Table 5. Training types for survey respondents

Characteristic	N = 134[1]
Before lockdown, were you engaging in other forms of exercise?	
Resistance Training at Another Studio	6 (4.5%)
Resistance Training at Home	9 (6.7%)
Cardio at Another Studio	26 (19%)
Cardio at Home	92 (69%)
Other Training	36 (27%)
Since lockdown, have you engaged in Virtual Training?	119 (89%)
What would make you more likely to try Virtual Training?[2]	
Research demonstrated Virtual Training produced the same results as in a gym/studio	4 (3.0%)
If I were more comfortable with technology	1 (0.7%)
If I knew more people like me were engaged in Virtual Training	0 (0%)
If I had more equipment/weights at home to use in Virtual Training	5 (3.7%)
Other	6 (4.5%)
Since lockdown, have you engaged in Studio Training?	118 (88%)
Since lockdown, how are you predominantly training?	
Combination of Studio and Virtual	17 (13%)
In Studio Only	96 (72%)
Not Currently Training	1 (0.7%)
Virtual Only	20 (15%)

[1] n (% of total N); [2] Asked to those respondents who had not tried Virtual Training

From pre- to during lockdown there was a small increase in the number of respondents purchasing equipment for resistance training and indeed a small majority of those who had not purchased prior to lockdown did purchase some during (figure 1). Both pre- and during lockdown the majority spent up to 500 USD on these purchases. Frequency of training remained largely unchanged with a minority shifting from either once to twice a week or vice versa (figure 2). Perception of effort also remained stable with respondents reporting a median of 9 out of 10 (where 10 indicates maximum perception of effort) at both pre- and during lockdown (figure 3). Participants goals also remained unchanged for the majority with only a small number of participants reporting changes from pre- to during lockdown (see diagonals in figure 4) and as such the majority also perceived their current training during lockdown to be similarly effective for these goals compared to their training pre-lockdown (figure 5). Most respondents also reported that their current motivation, enjoyment, perception of supervision quality, and likelihood of continuing their current training was either similar or higher than pre-lockdown (figure 6). Lastly, despite a wide range of responses (0% to 50%), the modal increase from the posterior probability distribution for smallest meaningful change in strength was 10.1% (95% HDI, 9% to 11.6%; figure 7).

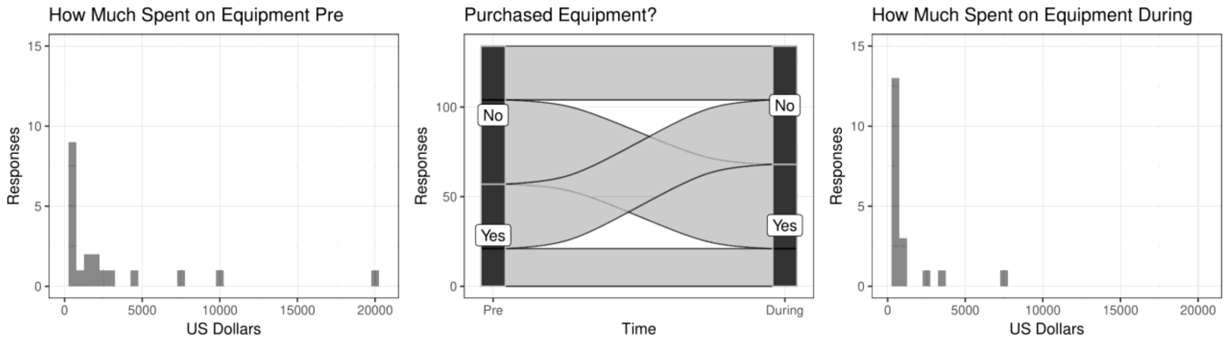

Figure 1. Purchases of equipment for resistance training.

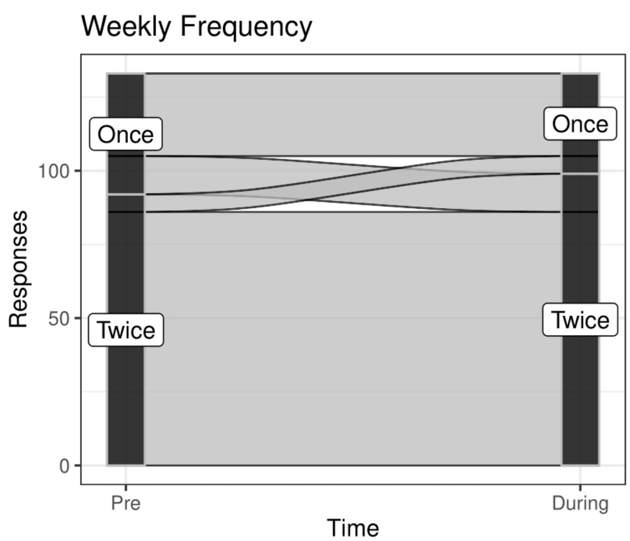

Figure 2. Frequency of training per week.

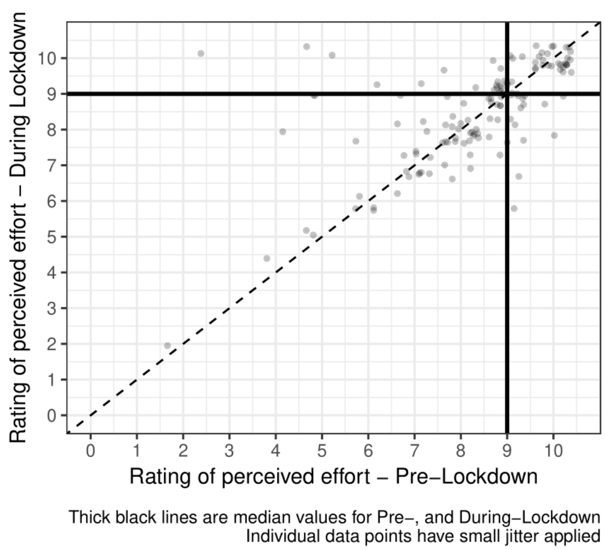

Figure 3. Ratings of perception of effort.

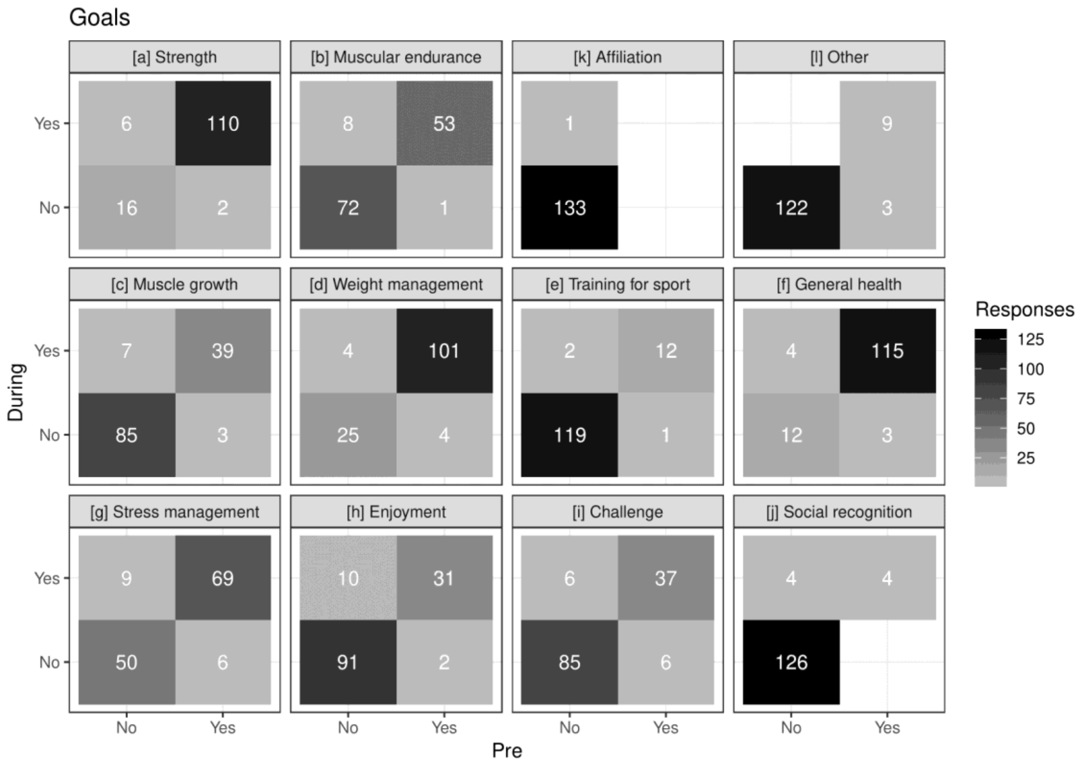

Figure 4. Goals for resistance training.

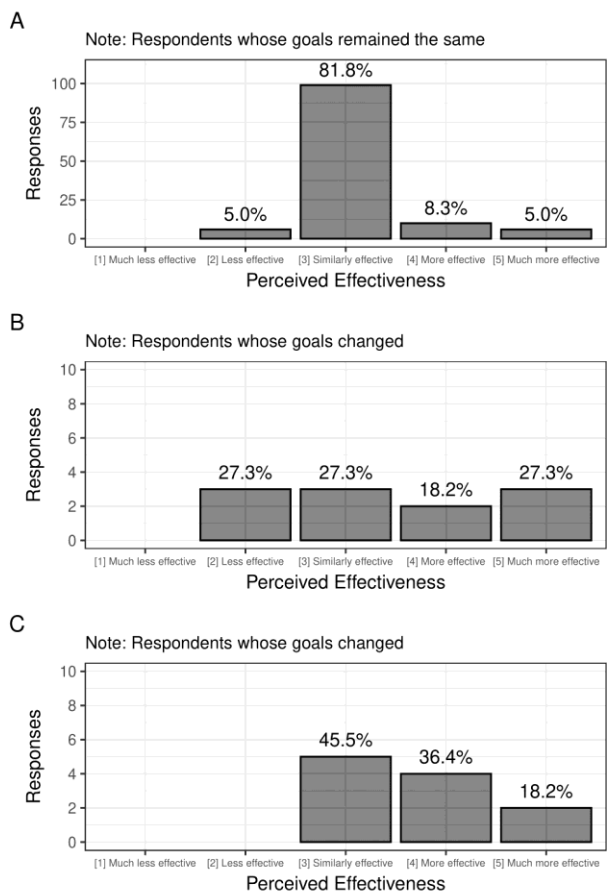

Figure 5. Perceived effectiveness of training for goals; A) current goals in those whose goals remained the same, B) prior goals in those whose goals changed, and C) current goals in those whose goals changed.

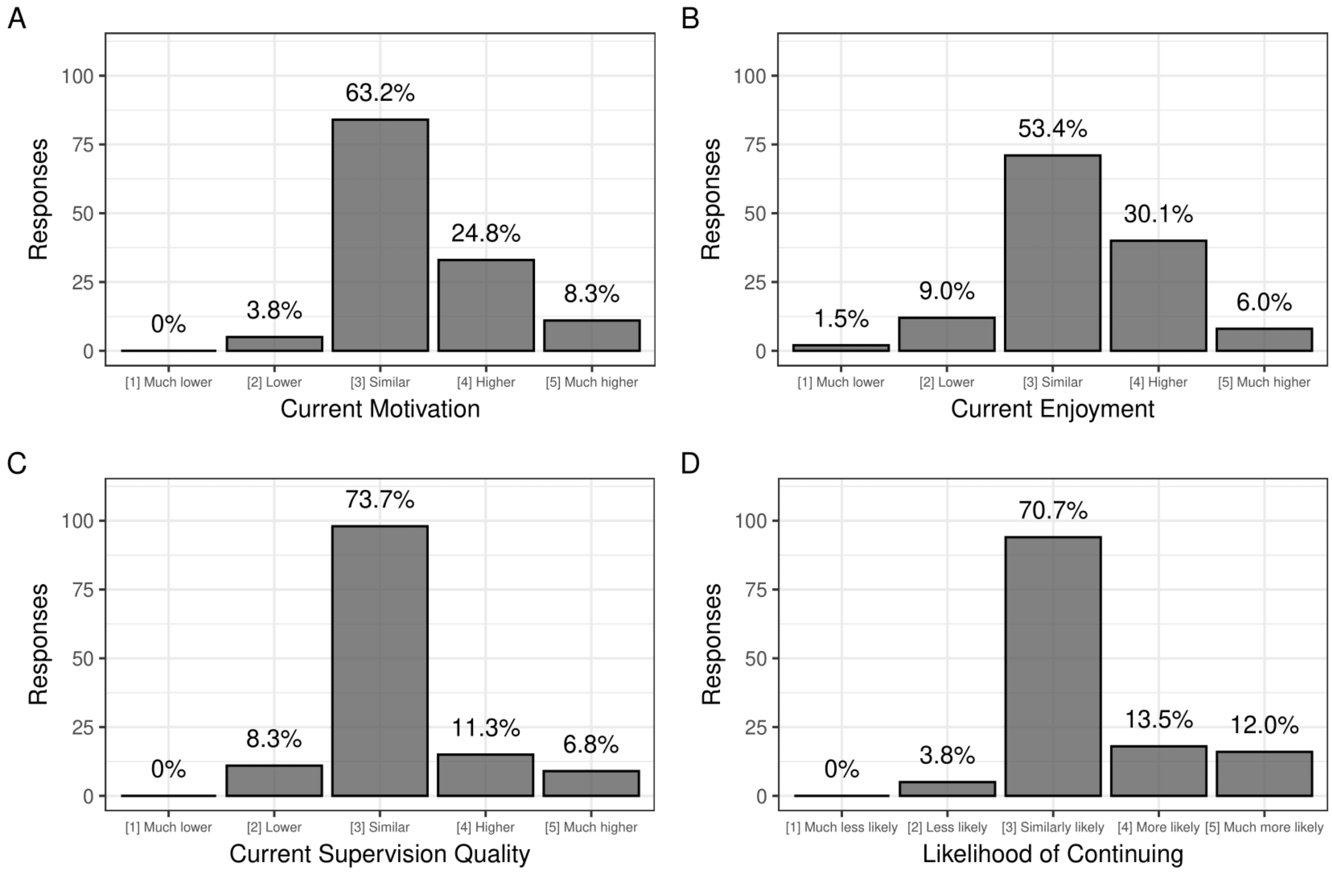

Figure 6. Current motivation, enjoyment, perception of supervision quality, and likelihood of continuing current training.

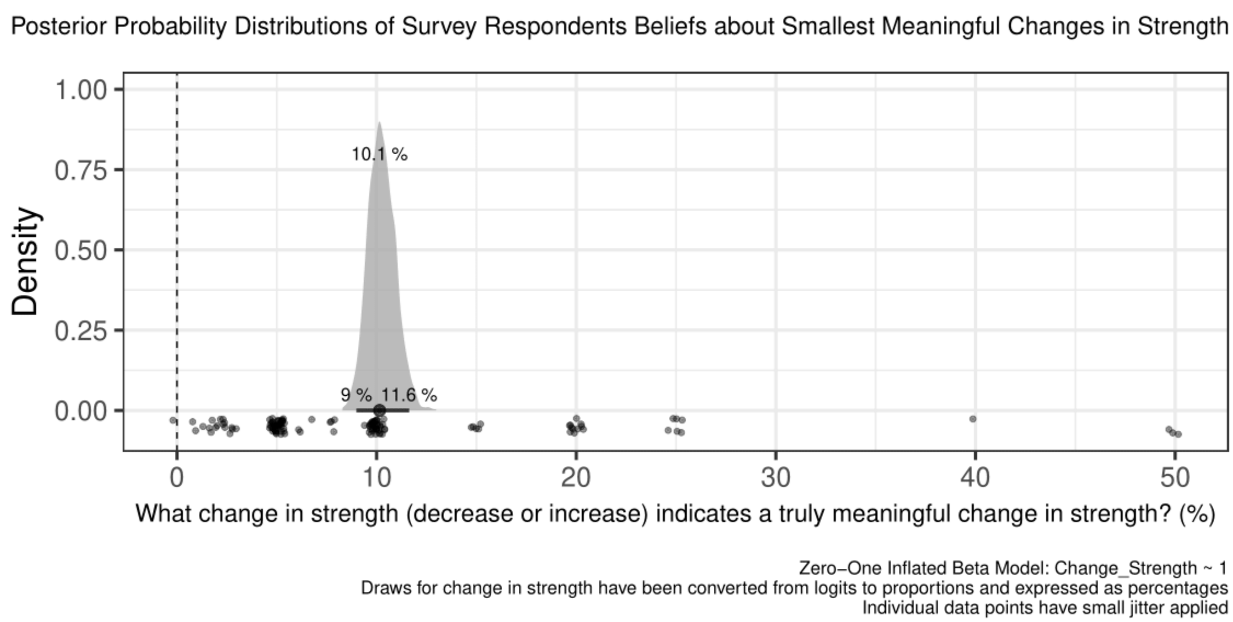

Figure 7. Posterior probability distribution of smallest meaningful changes in strength. Point and interval (along with numbers on the distribution) are the mode and 95% HDI.

Intervention Effects

For both strength and fat mass outcomes we observed minimal changes as a result of either intervention, with little difference between them. Indeed, for all outcomes the entirety of the posterior probability distribution fell within the ROPE. Given the model, there is a 100% probability that both interventions essentially maintained both strength and fat mass similarly. Figure 8 shows the posterior probability distributions of estimated marginal means for each outcome and condition in comparison to the ROPEs, along with the modes and 95% HDI and individual participant data points.

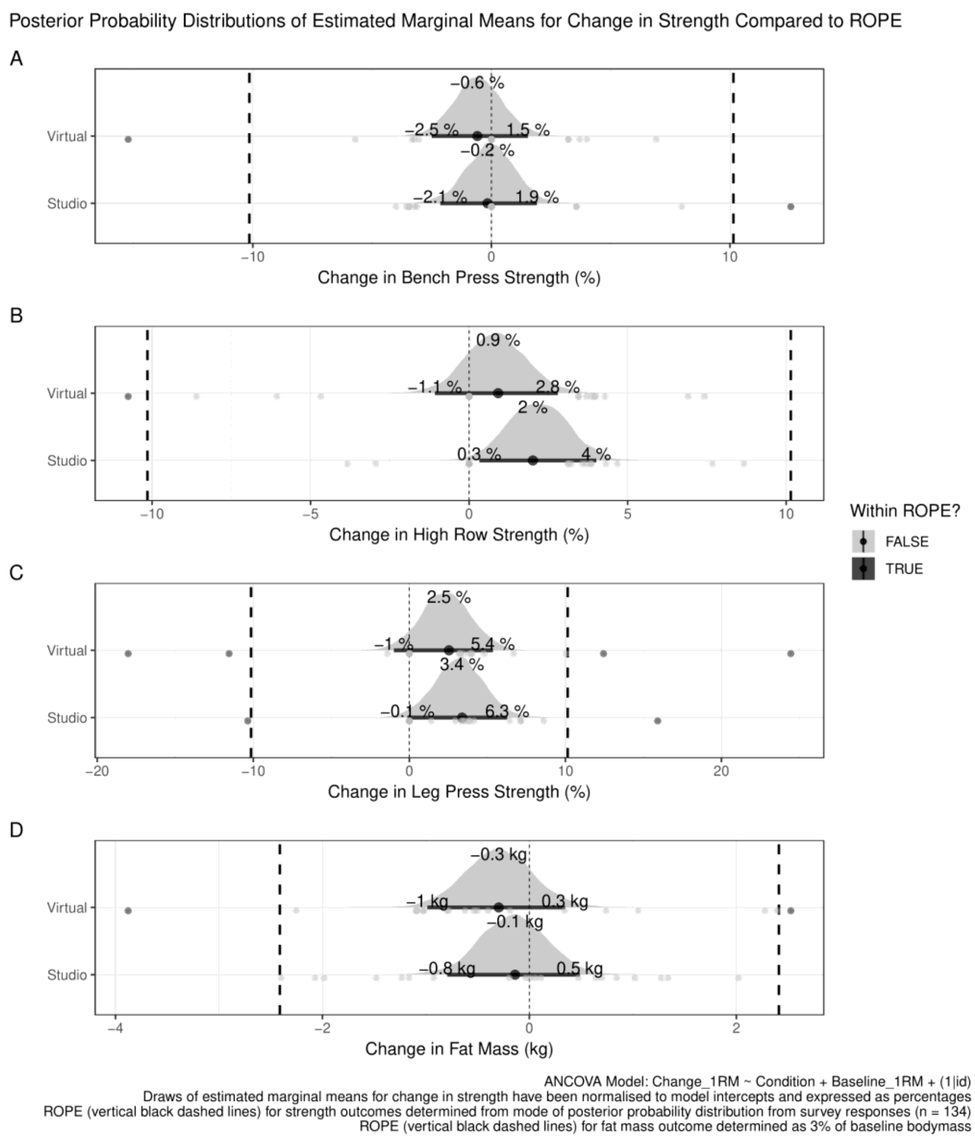

Figure 8. Posterior probability distributions for estimated marginal means compared to ROPE distributions for strength (A, B, and C) and fat mass (D) outcomes. Point and interval (along with numbers on the distribution) are the mode and 95% HDI.

Discussion

This represents the first empirical research with trained males and females comparing virtual-, to traditional supervised studio-based-, resistance training. Notably, the parallel-group, crossover design presents a methodologically rigorous approach to comparing virtual and traditional studio supervised between-group resistance training (Dwan, et al. 2019).

Firstly, considering the survey data, from pre- to during lockdown there was a small increase in the number of respondents purchasing equipment for resistance training. This is probably as expected in persons undertaking regular and structured exercise, and is consistent with previous data (Steele, et al. 2021; Ruiz-Roso, et al. 2020). Frequency of training remained largely unchanged in the surveyed participants, and, once again, this is in alignment with previous findings which suggests training frequencies showed little difference between pre- and during-lockdown in the lay population (Steele, et al. 2021). However, in a survey of athletes, there was a trend for frequency of training to decrease during lockdown and gym closures (Jagim, et al. 2020), although it should be noted that for athletes "*training*" included 'conditioning activities', 'mobility and flexibility', and 'sport-specific activities', in contrast to the present survey which asked solely after resistance training practices.

Interestingly, data from the present survey suggested perception of effort remained stable with respondents reporting a median of 9 out of 10 (where 10 indicates maximum perception of effort) at both pre- and during lockdown. This contrasts with our previous research (Steele, et al. 2021) which reported values for intensity of effort generally decreasing during lockdown. However, previous data showing such a decrease considered a larger population group that might have been less familiar with supervised, high-effort resistance training. Furthermore, our data shows that 89% of people transitioned to virtual personal training during lockdown. In this sense, we can assume that virtual personal training, at the least by this facility, is an efficacious approach to permit continued engagement in high intensity of effort resistance training. This might be of importance for the maintenance and improvement of physiological adaptations since effort seems a key driver for hypertrophic adaptations in trained persons (Grgic, et al. 2021) and where similar adaptations are attainable with both heavier- and lighter-loads (Fisher, et al. 2020; Schoenfeld, et al. 2021) and both equipment- and bodyweight-based exercise (Kikuchi et al., 2017; Kotarksy et al., 2018).

Participant goals also remained unchanged for most survey respondents with only a small number of participants reporting changes from pre- to during lockdown and, as such, the majority also perceived their current training during lockdown to be similarly effective for these goals. In considering the responses to the present survey in comparison to those reported by Jagim, et al. (2020) we can see the contrast in motivations between the lay population and athletes. In our own survey, responses were notably high for the goals of *strength*, *general health*, and *weight management*, whereas those reported by Jagim, et al. favoured *training for competition/sport*. In our own survey training for sport was resoundingly answered as not being a goal pre- or during lockdown (119 of the 134 respondents), further differentiating the demographic. This aligns with previous research considering motives for participation in resistance training which suggests that those undertaking 1-on-1 personal training rated *ill-health avoidance*, *positive health*, *strength and endurance*, and *weight management* highest, compared to other possible motives such as affiliation, competition, and social recognition (Fisher, et al. 2017a). Furthermore, most respondents also reported that their current motivation, enjoyment, perception of supervision quality, and likelihood of continuing their current training was either similar or higher than pre-lockdown. Since 89% of these people had transitioned to virtual personal training, this might support and the perceived effectiveness of virtual resistance training.

Lastly, despite a wide range of responses (0% to 50%), the modal increase from the posterior probability distribution for smallest meaningful change in strength was 10.1%. Analysis of data from our intervention suggested that both interventions essentially maintained both strength and fat mass similarly, since neither group crossed this threshold for smallest worthwhile change. In fact, it is optimistic to think that strength increases might surpass 10% within 3-weeks of training in an already resistance trained person given the diminished response to training with increased training experience (Steele et al., 2021b). However, considering that 3-weeks of training cessation can result in loss of training induced gains (Ogasawara et al., 2013) this should be considered a positive outcome for virtual personal training using minimal equipment and bodyweight. For maintenance at least, it is as effective as 1-on1 personal training within a studio and using traditional resistance training equipment (e.g. machines and free weights). Indeed, previous research has supported that load, and resistance type (e.g. free-weights, resistance machines, and bodyweight) are of lesser importance where intensity of effort is high (Fisher, et al. 2017b, Fisher, et al. 2011).

The present study is not without some limitations that should be acknowledged. Firstly, whilst similarities in the responses were evident between the present survey and the current body of literature (e.g. Steele, et al. 2021; Jagim, et al. 2020), this survey was only conducted with existing clients of the Discover Strength chain of strength training facilities. That is to say, all respondents were training 1x or 2x /week using high effort (i.e., training to momentary failure and occasionally using advanced training techniques such as drop-sets, pre- or post-exhaustion, forced repetitions, etc.), low-volume (i.e., a single set of each exercise) supervised resistance training sessions. As such we cannot assume the data presented is representative of a larger population following other resistance training practices. We should also recognise the limited sample size and duration of the strength training intervention. We posit that many researchers will struggle to comprehensively change the practices of a resistance trained population. Further, that persons engaging in resistance training regularly might only transition to virtual personal training when necessary (e.g. during closure of fitness facilities, when travelling, or when unable to attend their normal facilities) – although our data suggests that virtual personal training might be an efficacious replacement to traditional studio based strength training. However, while our data suggests efficacy of supervised virtual personal training compared to supervised studio training, differences in adaptation might become evident over a longer time epoch. Future research might consider the long-term effectiveness of virtual personal training both for physiological and perceptual outcomes.

Conclusions

Based on the current data, it appears that short-term supervised virtual resistance training is as efficacious as traditional supervised studio-based resistance training. Further, that virtual supervision of resistance training through a virtual platform can perceptually maintain the intensity of effort, motivation, enjoyment, and supervision quality, compared to traditional supervised studio training.

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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/q8d4r/

Author contributions

All authors conceived of, and designed, the study; LC and DG collected the data; JS carried out statistical analyses; all authors were meaningfully involved in interpreting data, and drafting and critically revising the manuscript for intellectually important content.

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