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The impact of duration on effectiveness of exercise, the implication for periodization of training and goal setting for individuals who are overfat, a meta-analysis

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ABSTRACT: Given the assumption that all methods of exercise, e.g., endurance (ET), resistance (RT), or combination of both (E+R), can induce a beneficial effect size (ES) for changes in body composition and health status of individuals who are overfat. Thus the aim and purpose of this study is to evaluate the current body of knowledge to address the question as to the impact that the duration of exercise has on its relative effectiveness for inducing health and body compositional changes in individuals who are overfat to assist with developing periodized exercise protocols and establishing short and long term goals. A tiered meta-analysis of 92-studies and 200-exercise groupings were used for establishing pooled ES within and between groupings based on the increments of 4-week of duration and study designs of ≤8, 9-16, 17-23, 24-36, and ≥36 weeks. Analysis based on random-effect of response indicates a continuum of effectiveness within and between ET, RT and E+R based on duration. Where beneficial effectiveness is not indicated for any measures until after 8-weeks of continuous training with progressive effectiveness being noted in changes to cardiorespiratory fitness, inflammatory cytokines, and alteration of metabolic status from 12-weeks through 32-weeks of continuous training. Results indicate a greater ES for RT and E+R versus ET early in intervention that equalizes with longer durations. Supporting the use of RT and E+R within a periodized program. And secondarily, goals should be established first on performance gains and second body composition or health status modifications for the individual who is overfat.

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INTRODUCTION

Over the past century, the use of exercise, e.g., endurance exercise (ET), resistance exercise (RT), or endurance and resistance combined (E+R), has become a common treatment method for improving body composition and health status of individual who are overfat, i.e. the individual with health issues arising from excessive body fat and not from body mass index (BMI) classification of obese or overweight, or for those individuals with metabolic issues, e.g., type 2 diabetes mellitus or MetS [1, 2]. Resulting in a multitude of institutional position stands and exercise programs (with or without a concurrent change in diet) in an attempt to improve the overall health status and body composition for individuals who are overfat or with metabolic syndrome (T2DM) [3-11]. Each developed in the global effort to deal with the epidemic rise in the rate of overfatness (and the associated health issues) within the global population, universally based on the premise that doing any type of activity is better than doing no activity at all [7-9, 12]. That is furthered by the postulate that increasing overall level of physical activity for the individual who is overfat will ultimately produce a change in behavior that alters an unhealthy lifestyle into a healthy lifestyle [5, 10].

Abbreviations:

ES	– effect size as determined by pooled effect size via random effect computation
ET	– Endurance Training
RT	– Resistance Training
E+R	– combination of ET and RT
BM	– body mass (kg)
BMI	– ($kg \cdot m^{-2}$)
FM	– fat mass (kg, or as determined by %body fat)
FFM	– fat-free mass (kg, or as determined by %fat-free mass)
T2DM	– type 2 diabetes mellitus or metabolic syndrome
CRP	– C-reactive protein
TNF-α	– tumor necrotic factor-alpha
IL-6	– interleukin-6
VO_2max	– maximal aerobic capacity
HRmax	– maximal sustainable heart rate
1RM	– maximal level of resistance for a single repetition (i.e. maximal strength)
SBP	– systolic blood pressure
DBP	– diastolic blood pressure

However, issues arise related to the ideal of exercise incorporation into treatment for the individual who is overfat. Principally, given the known value of exercise, why does exercise have such a poor attrition rate in the utilization and compliance with the recommendation for exercise by the population as a whole [13-15]? An answer to which most likely stems from multiple factors, notably the application bias by health professionals coupled to the social stigma individuals who are overfat face in the development of exercise programs [14, 16-19]. Which combine with the limited appreciation for the complexity of exercise, or responses to exercise, that impact the individual's physiology leading to the changes in overall health status of the individual who is overfat [1, 2, 20]. The former may limit the draw that the individual has to exercise while the latter limits the ability to design exercise programs based on a periodization model [21, 22] that would allow for modification of the level of stimulus across the duration of training. A model of application that is necessary for continual physiological, and morphological, adaptations and improvements in overall health status to take place [2, 14]. Ultimately, poor exercise design and application limits the ability to modify long-term health behaviors required to encourage the modifications necessary to convert the overfat individual from a diseased health status to a non-diseased health status [1, 5, 8]. Thereby, producing the poor attrition and compliance with exercise programs.

While a recent meta analysis has indicated differences in effectiveness between methods of exercise, based on level of total muscle stimulation that favors use of higher levels of training stimulus over lower-levels [23]. In which, higher level stimulus from resistance training (e.g., hypertrophic patterning) shows as being the most effective pattern of training stimulus for inducing changes in morphology and health status of the individual who is overfat [23]. Yet, there appears to be a bias in the promotion of methods of exercise at low overall stimulus versus those of higher level of stimulus. Along with a premise that any increase in activity has benefit and that exercise methods generate a similar level of adaptation, if we just give it enough time [9, 19, 24-26]. Generating a mismatch of unrealistic expectations for outcome from exercise, as stimulus generally promoted is not high enough to produce changes generally desired, along with a lack of modification within the training stimulus to provide for continual and progressive modifications to both body composition and health status. Thus, leading to the poor adherence and lower attrition rate to multiple methods of exercise for individuals who are overfat or at risk for metabolic issues [13-15]. And may explain the cyclic behavior of repetitive attempts of, and withdrawals from, various exercise methods to fulfill the want of improved overall health of the individual who is overfat.

Thus we are left with questions about the means by which to prescribe exercise based on how long must one engages in these methods of exercise to stipulate that a program works? And if it takes disproportionately longer for one program to work, is it actually as effective as another program? Where answers can allow us to determine the time course for overall effectiveness from different methods of exercise and therefore develop first a time course for goal setting and secondly, a method for the periodization of training. That will allow for us to provide an exercise program that provides the greatest degree of benefit and the changes in long-term patterns of physical activity and exercise behaviors to alter the overall health status of the individual who is overfat, or susceptible to metabolic issues.

Therefore, the purpose here is to expand upon previous reports of effectiveness [23] related to changes in body composition and issue of overall health status of the individual who is overfat based on the duration of exercise. Testing the hypothesis that the relative benefit obtained from exercise will become more effective with prolonged exposure to any of the exercise modalities, e.g., endurance, resistance, or combination of endurance and resistance training. And secondarily, inclusion of resistance exercise within training program will continue to show a greater level of effectiveness for eliciting responses across all durations examined for each measures of interest. Where the aim this study is to evaluate observational, tracking and random-control trials to address the impact that the duration of exercise has on its relative effectiveness for inducing health and body compositional changes in individuals who are overfat. So as to provide an understanding as to what, if any, differences exist across the duration of exercise that is required for development of a periodized program of exercise prescription. While also providing the information necessary for developing both the short and long-term goals for the exercise protocols for individuals who are overfat.

MATERIALS AND METHODS

The meta-analysis is a continuation of analysis that has been previously detailed [23] examining the random-effect pooled effect size (ES) for responses in adults who are overfat, clustered for the duration of exercise used in treatment. In which relevant studies (e.g., studies only involving human volunteers within population based research models) were retrieved from electronic database search engines (PubMed, SPORTDiscus, Scopus) through the end of February 2014. Where the searches were conducted based on the key word *human,* with a combination of any (or all) of the following: *obesity, type 2 diabetes, metabolic syndrome, exercise, resistance training or resistance exercise, endurance training or aerobic exercise, strength training, diet, insulin, obesity, weight loss, fat mass, and fat-free mass.* From the 3,500 total journal articles, see PRISMA information in supplemental figure 1, returned by the search engines and following the initial screening a total of 92 studies were included based on the following criteria into the meta-analysis:

Inclusion criteria

Published original research from January 1980-February 2014

- Published in English or translation of article available
- Utilized only human participants with reported average age ($\bar{X}_{\text{age}}$) for volunteers ranging from 18 and 65 years of age during the duration for the experiment
- Study population was either identified as either "overweight" or "obese" by authors or was indicated within the study as meeting at least 1 of the classification metrics for being overweight or obese and indicated elevated fat-mass as cause for classification

- Studies involved observational and tracking of changes following intervention, involved a comparison at least two conditions (either within subject cross-over design or comparison to a control or basal/baseline) with possible random assignment to training group(s) or control and to the order or method of training
- Study designs examined chronic adaptations (i.e. multiple training sessions, or interventions lasting at least 4 weeks in duration)
- Study reported average values and standard deviations for measures observed from intervention for both the pre-test and post-test values
- Main purpose was to examine hormonal or cellular responses to exercise
- Main purpose was to examine changes in body mass in response to exercise
- Main purpose was to examine chronic responses to either modes of exercise (e.g., resistance exercise or endurance exercise) or combination of one of the exercise modes with hypocaloric diet, or combination of both modes of exercise (e.g., combination of resistance and endurance exercise within training regimen) with or without a hypocaloric diet

Exclusion criteria

- Publication was a review article
- Not published in English or no translation available
- Study design utilized an animal model for the problem
- Population age could be classified as adolescent, or juvenile, ($\bar{X}_{age}$ < 18 years of age) and/or elderly ($\bar{X}_{age}$ > 65 years of age)
- Study population either failed to meet metrics for classification as "obese" or "overweight", or was indicated to have secondary disease (e.g., cancer, osteoporosis, cardiovascular disease) or had populations indicated to have history of metabolic variables and concurrent treatments (e.g., smoking, pharmacologically controlled type-2 diabetes mellitus (T2DM), cardiovascular diseases) that might confound the response to exercise and/or diet treatment
- Study design examined strictly acute responses (i.e., single exercise bout, or intervention lastly fewer than 4 weeks in duration)
- Study reported percentage of changes without indication of averages and standard deviation of pre- and post-test values
- Main purpose did not involve measure of hormonal or cellular response to exercise or diet
- Results did not report absolute changes in hormones or body mass following intervention
- Indication of use of dietary supplement, or pharmacological dosing of anabolic or androgenic hormones
- Due to the inability to blind participants to whether or not the individual has been exposed to exercise, studies were not excluded by the criteria of random-control blinding to treatment.

From the 92 studies, 200 study-groupings were developed for comparison of responses within the review across the duration of studies and then chronological time of continuous training. These groupings were based on study demographics, e.g., age, gender, overfatness and disease state, followed by the method of exercise indicated, e.g., endurance (ET), resistance (RT), or endurance and resistance combined (E+R) and then by indication of relative intensity of training. Classification of exercise was performed, regardless of additional dietary intervention to the exercise regimen, as it was previously noted that diet (except for lower carbohydrate diet) had a minimal overall impact on the exercise's level of effectiveness for adaptations in measures of interest analyzed here [23]. After entry of study demographics, each study was identified by the duration of exercise intervention, by total number of weeks of training, and the group size for human volunteers within each group for that study. After which the reported averages (pre-, and post-, test) and standard deviations of each test for all measures of interest (e.g., body mass (BM), fat mass (FM), fat-free mass (FFM), body mass index (BMI), systolic (SBP) and diastolic (DBP) blood pressure, aerobic fitness (VO_{2max}), $[insulin]_{pl}$, $[glucose]_{pl}$, [glycated hemoglobin $(A1c)]_{pl}$, $[adiponectin]_{pl}$, $[leptin]_{pl}$, [c-reactive protein $(CRP)]_{pl}$, and [tumor necrotic factor- α $(TNF\text{-}\alpha)]_{pl}$) were entered into the data table. To determine the progressive change in ES within and between exercise methods for eliciting changes in these measures studies were clustered based on the length of investigation for each study included at ≤8-weeks (19-studies [27-45], group size: 19±6.4, age: 45±10.2, female:male ratio: 1.6), 9-15 weeks (29-studies [46-73], group size: 19±22, age: 47±10.4 , female:male ratio: 1.3), 16-23 weeks (16-studies [44, 74-88], group size: 15±11.4, age: 52±9.5, female:male ratio: 1.3), 24-36 weeks (14-studies [35, 71, 77, 89-99], group size: 41±27.9, age: 55±6.3, female:male ratio 0.9) and >36-weeks (15-studies [77, 89, 91, 100-111], group size: 53±46.4, age: 46±9.2, female:male ratio: 1.14), see supplemental table 1, and then grouped within these clusters by 4-week increments of continuous training for examination of within grouping changes.

Analysis of tabulated results was performed to determine the degree of skew (that is only due to publication bias toward only reporting the positive findings and dissimilar exercise parameters within studies) within the responses to assess the likelihood of continuing analysis utilizing aggregate pooled effect based on the method previously utilized [23, 112]. There was an active attempt to limit the selection bias of studies included by examining all study methods used to evaluate intervention programs that used exercise, beyond the classically desired random-controlled and clinical trails. In this effort, population demographics were also evaluated to ensure that populations within each study was not so restrictive as to limit the generalizability of the findings provided by the authors of that study. Based on such analysis, bias in the data indicated that relative effectiveness for eliciting changes must be conducted utilizing a non-parametric, non-uniform method for the determination of ES across and between methods of exercise for the durations performed. Where all grouped analysis is based on the assumption of random-effect pooled effect size, similar to what this author previously performed and reported on [23, 112, 113]. The determined pooled ES, and resultant confidence intervals ($CI_{.95}$) of ES was determined, to examine the overall effect relative to a case of no change (i.e. ES=0.00 or a $CI_{.95}$ for ES crossing zero within range for expected responses) as previously described [23, 112].

The comparisons analyzed here are based on each of the following 1) within and across all the various exercise modalities, e.g., all exercise (All Ex), endurance exercise (ET), resistance exercise (RT), or combination of endurance and resistance (E+R), based on clustering of groups within 4-week increments of training duration from 4-weeks to 40-weeks and then at 52-weeks of exercise training; 2)

TABLE I. Summary of the effectiveness, ES (low $CI_{.95}$, high $CI_{.95}$), for eliciting changes in response of measure of interest between the various methods of exercise based on the durations of training.

	BM	FM	FFM	BMI	SBP	DBP	VO_2	Insulin	Glu	A1c	OB	Adip	IL-6	CRP	TNF-α
Within ≤8-weeks of training															
ET v. RT	-0.11 (-0.49, 0.27)	-0.39 (-0.80, 0.02)	-0.26 (-0.84, 0.01)	-0.28 (-0.73, 0.17)	0.00 (-0.71, 0.71)	-2.45 (-3.77, -1.13)	-0.69 (-1.33, -0.04)	0.04 (-0.46, 0.54)	-0.16 (-0.63, 0.31)	-0.15 (-0.69, 0.39)	0.07 (-0.87, 0.14)	-0.37 (-0.87, 0.14)	-0.26 (-1.26, 0.75)	-0.94 (-1.99, 0.12)	-0.38 (-1.20, 0.45)
ET v. E+R	-0.26 (-0.62, 0.11)	-0.40 (-0.83, 0.03)	-0.18 (-0.89, 0.53)	0.09 (-0.28, 0.45)	---	---	0.60 (-0.12, 1.09)	0.32 (-0.63, 0.90)	0.07 (-0.44, 0.57)	0.22 (-0.28, 0.72)	-0.19 (-0.63, 0.26)	0.21 (-0.19, 0.64)	-0.19 (-0.82, 0.44)	-0.23 (-0.94, 0.48)	-0.55 (-1.27, 0.17)
E+R v. RT	0.02 (-0.37, 0.42)	-0.03 (-0.46, 0.39)	-0.08 (-0.78, 0.63)	-0.21 (-0.68, 0.27)	---	---	-1.26 (-1.35, -0.54)	-0.23 (-0.86, 0.41)	-0.17 (-0.71, 0.37)	-0.30 (-0.88, 0.28)	0.20 (-0.25, 0.65)	-1.02 (-1.64, -0.41)	0.22 (-0.42, 0.85)	-0.55 (-1.27, 0.17)	0.21 (-0.61, 1.03)
Within 9-15 weeks of training															
ET v. RT	-0.05 (-0.31, 0.20)	-0.34 (-0.59, -0.08)	-0.18 (-0.48, 0.13)	-0.08 (-0.36, 0.20)	0.41 (0.13, 0.95)	0.13 (-0.41, 0.66)	0.24 (-0.06, 0.53)	-0.17 (-0.67, 0.34)	-0.10 (-0.61, 0.40)	-0.22 (-0.65, 0.21)	0.02 (-0.62, 0.65)	-0.13 (-0.52, 0.26)	-0.29 (-0.83, 0.24)	0.05 (-0.59, 0.68)	-1.10 (-1.78, -0.42)
ET v. E+R	-0.12 (-0.41, 0.18)	-0.19 (-0.51, 0.12)	-0.25 (-0.62, 0.11)	-0.07 (-0.37, 0.25)	-0.73 (-1.33, -0.14)	0.24 (-0.34, 0.82)	0.41 (0.08, 0.73)	-0.15 (-0.63, 0.32)	0.09 (-0.46, 0.48)	0.06 (-0.32, 0.44)	---	-0.20 (-0.65, 0.25)	0.04 (-0.60, 0.67)	0.02 (-0.56, 0.59)	0.23 (-0.59, 1.05)
E+R v. RT	0.03 (-0.39, 0.46)	-0.34 (-0.70, 0.03)	0.11 (-0.32, 0.53)	-0.08 (-0.51, 0.35)	1.35 (0.45, 2.26	-0.13 (-0.95, 0.68)	-0.10 (-0.55, 0.43)	0.21 (-0.61, 1.02)	-0.11 (-0.92, 0.71)	-0.54 (-1.13, 0.05)	---	0.13 (-0.45, 0.71)	-0.30 (-1.12, 0.53)	0.05 (-0.66, 0.76)	-1.09 (-1.97, -0.22)
Within 16-23 weeks of training															
ET v. RT	0.07 (-0.26, 0.40)	0.23 (-0.16, 0.62)	0.02 (-0.43, 0.46)	0.04 (-0.35, 0.44)	0.25 (-0.23, 0.72)	0.13 (-0.34, 0.61)	0.23 (-0.20, 0.66)	0.63 (0.17, 1.08)	0.38 (-0.03, 0.79)	0.11 (-0.32, 0.53)	---	-1.06 (-1.93, -0.18)	---	-0.50 (-1.07, 0.10)	---
ET v. E+R	-0.26 (-0.59, 0.08)	-0.08 (-0.48, 0.31)	0.02 (-0.43, 0.46)	-0.55 (-1.00, -0.09)	-0.13 (-0.63, 0.34)	-0.30 (-0.80, 0.20)	0.43 (-0.03, 0.88)	0.58 (0.10, 1.06)	0.07 (-0.38, 0.52)	-0.77 (-1.26, -0.29)	---	0.39 (-0.25, 1.03)	---	0.03 (-0.67, 0.70)	---
E+R v. RT	0.32 (-0.02, 0.65)	0.33 (-0.05, 0.71)	0.00 (-0.37, 0.38)	0.65 (0.21, 1.09)	0.35 (-0.29, 0.99)	0.45 (-0.19, 1.09)	-0.15 (-0.79, 0.48)	-0.01 (-0.49, 0.46)	0.31 (-0.20, 0.81)	0.82 (0.30, 1.34)	-1.61 (-2.55, -0.87)	-0.86 (-1.91, -0.18)	---	---	---
Within 24-36 weeks of training															
ET v. RT	0.28 (-0.06, 0.61)	-0.77 (-1.13, -0.40)	-0.07 (-0.46, 0.33)	0.70 (0.25, 1.13)	---	---	0.55 (0.13, 0.96)	0.21 (-0.27, 0.68)	0.03 (-0.47, 0.53)	0.57 (0.09, 1.05)	---	---	---	---	---
ET v. E+R	-0.13 (-0.51, 0.24)	-0.12 (-0.53, 0.29)	-0.03 (-0.50, 0.44)	-0.11 (-0.56, 0.33)	---	---	0.09 (-0.32, 0.50)	---	0.03 (-0.47, 0.53)	0.41 (-0.06, 0.89)	---	---	---	---	---
E+R v. RT	0.49 (0.07, 0.90)	-0.72 (-1.19, -0.26)	-0.04 (-0.49, 0.41)	0.67 (0.12, 1.22)	1.00 (-0.06, 2.06)	0.41 (-0.60, 1.42)	1.09 (0.02, 2.16)	---	-0.01 (-0.82, 0.81)	0.15 (-0.43, 0.72)	---	---	---	---	---
Within >36-weeks of training															
ET v. RT	-0.33 (-0.72, 0.07)	-0.21 (-0.66, 0.24)	-0.44 (-1.08, 0.20)	-0.54 (-0.99, -0.08)	0.58 (-0.07, 1.23)	0.48 (-0.17, 1.12)	0.00 (-0.54, 0.54)	-0.09 (-0.80, 0.62)	0.07 (-0.47, 0.60)	-0.48 (-1.12, 0.17)	---	---	---	---	---
ET v. E+R	-0.34 (-0.75, 0.07)	-0.15 (-0.60, 0.29)	-0.44 (-1.07, 0.21)	-0.27 (-0.67, 0.12)	0.43 (-0.04, 0.91)	-0.18 (-0.65, 0.30)	-0.20 (-0.63, 0.23)	0.08 (-0.49, 0.66)	0.11 (-0.47, 0.69)	-0.06 (-0.59, 0.48)	---	---	---	7.14) (5.57, 8.70)	---
E+R v. RT	0.03 (-0.60, 0.66)	-0.09 (-0.80, 062)	-0.13 (-1.13, 0.88)	-0.38 (-0.86, 0.10)	0.43 (-0.11, 0.90)	0.67 (0.16, 1.28)	0.24 (-0.34, 0.82)	-0.15 (-0.85, 0.56)	-0.05 (-0.68, 0.59)	-0.42 (-0.96, 0.12)	---	---	---	---	---

Note: Note that comparisons based on endurance versus resistance training methods (ET v. RT), endurance versus combination of endurance and resistance training methods (ET v. E+R), combination of endurance and resistance versus resistance training methods (E+R v RT). Negative (-) values indicate favor toward the second exercise group in the comparison between the methods of exercise, while '---' indicates not enough studies in the group to determine pooled effect size and $CI_{.95}$.

within all the various exercise modalities, e.g., All Ex, ET, RT, or E+R, based on clustering of groups of study durations (≤8-weeks, 9-15 weeks, 16-23 weeks, 24-36 weeks and 52-weeks); and 3) differences between exercise modality (e.g., ET versus RT, ET versus E+R, RT versus E+R) based on clustering of groups of study durations (≤8-weeks, 9-15 weeks, 16-23 weeks, 24-36 weeks and 52-weeks). With results indicated as ES ($CI_{.95}$ low value, $CI_{.95}$ high value) when significant differences were noted, i.e. ES ≠ 0, and where $CI_{.95}$ did not include 0 within the range for ES.

In an effort to establish a secondary directionality for difference between exercise treatments, the within study treatment ES, $(\mu_{post\text{-}treatment} - \mu_{pre\text{-}treatment})/(\sigma_{pre\text{-}treatment})$, were then clustered for 4x4 χ^2 analysis to determine if there was any difference in the level of response between methods of exercise. In which the χ^2 analysis was utilized through identification of number of greater effectiveness and number of lesser effectiveness within each exercise and duration group based comparison to study's ability to elicit a greater, or lesser, level of effectiveness relative to the pooled effectiveness of comparison (i.e. ET versus RT, ET versus E+R, RT versus E+R) and a diet-only intervention that has been previously reported [23].

RESULTS

As indicated in figure 1-5 and supplemental figures 2-4, the responses for effectiveness (ES) in eliciting changes follows the trend of continuum for a differential level of ES toward eliciting beneficial responses based on the duration of training both within and between the methods of exercise, table 1. The spectrum of overall beneficial effect (i.e. ES≠0, or $CI_{.95}$ of ES not including 0.00) both within and between methods of exercise appears to wane and plateau as training progresses into ever-longer durations. As comparisons show that shorter duration training appear to be more effective than the moderate and longer durations and moderate duration training more effective than the longer durations.

Comparing the elicited responses within each study analyzed indications for differential ES favoring a specific type of exercise based on the duration of the exercise within the individual study relative to the ES from diet (previously reported [23]) or in comparison to the pooled ES for the methods of exercise being compared. One such indication is RT's ability to elicit a larger ES for altering DBP and glucose at longer durations (beyond 36-weeks) relative to ET (χ^2=3.48, p=0.02 and χ^2=3.49, p=0.04, respectively). Along with

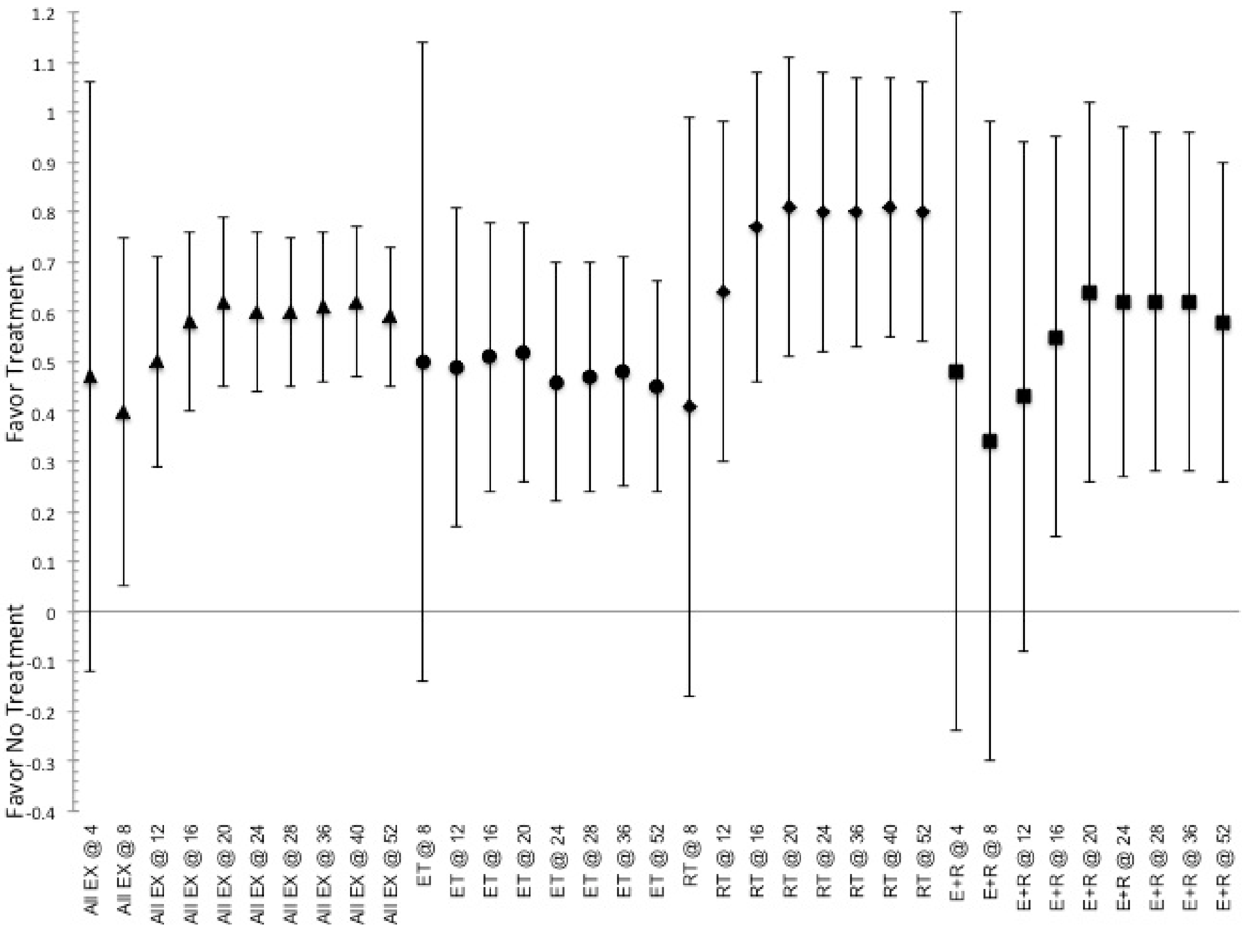

FIG. 1. Indicated pooled ES and $CI_{.95}$ for effective to elicit responses in measures of body morphology (fat mass) for the duration of training (indicated by @ and then number of weeks of training) based on exposure to stimulus of the various methods of exercise. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. ET indicated by ●, RT indicated by ♦, E+R indicated by ■, and All Ex indicated by ▲.

trends favoring RT for altering glucose through the moderate duration (up to 24-weeks) of training relative to ET, $\chi^2=1.28$ (p=0.12), and E+R (up to16-weeks), $\chi^2=1.49$ (p=0.13), and for changes in fasting insulin levels relative to ET, $\chi^2=1.77$ (p=0.14). Moreover, RT has a trend for being more effective at shorter durations (up to 8-weeks) for altering FFM and through the moderate durations (up to 24-weeks) for altering FM than ET, $\chi^2=1.24$ (p=0.15) and $\chi^2=1.38$ (p=0.12) respectively. Whereas, E+R trends toward being more effective than ET for altering FM through the moderate duration (up to16-weeks), $\chi^2=1.31$ (p=0.12), and after longer durations (beyond 36-weeks), $\chi^2=1.77$ (p=0.12), along with eliciting alterations in insulin, $\chi^2=2.11$ (p=0.11), after longer durations (beyond 36-weeks).

Effectiveness related to ability to elicit changes in morphology

Exercise has a greater ES at shorter and moderate durations, than at longer durations, with no indication for possible beneficial effects in changes of body morphology (BM, FM or FFM) occurring for each method of exercise until after 12-weeks of continuous training with changes in BMI not indicating a total beneficial effect until after 16-weeks, figure 1 and supplemental figure 2. The greatest ES for altering any measure of body morphology, with the exception of FFM, occurring at a training duration of 16-23 weeks, with the greatest ES for altering BM continues through 36-weeks of training, ES=0.47 (0.17, 0.78). Within the grouping analysis for each type of exercise notes that the use of RT and E+R appear to be more effective than ET, however the $CI_{.95}$ can have an ES of 0 and thus differences may not be significantly more effective for all duration, figure 1 and supplemental figure 2. RT becomes effective (i.e., $CI_{.95}$ always favoring treatment) at altering FM within the shorter training duration, ≤8-weeks, and all other measures of morphology at 9-15 weeks, while ET and E+R develop similar beneficial effectiveness after moderate and longer duration training periods, e.g., beyond 16-weeks of continuous training, regardless of the measures of body morphology being examined, figure 1 and supplemental figure 2.

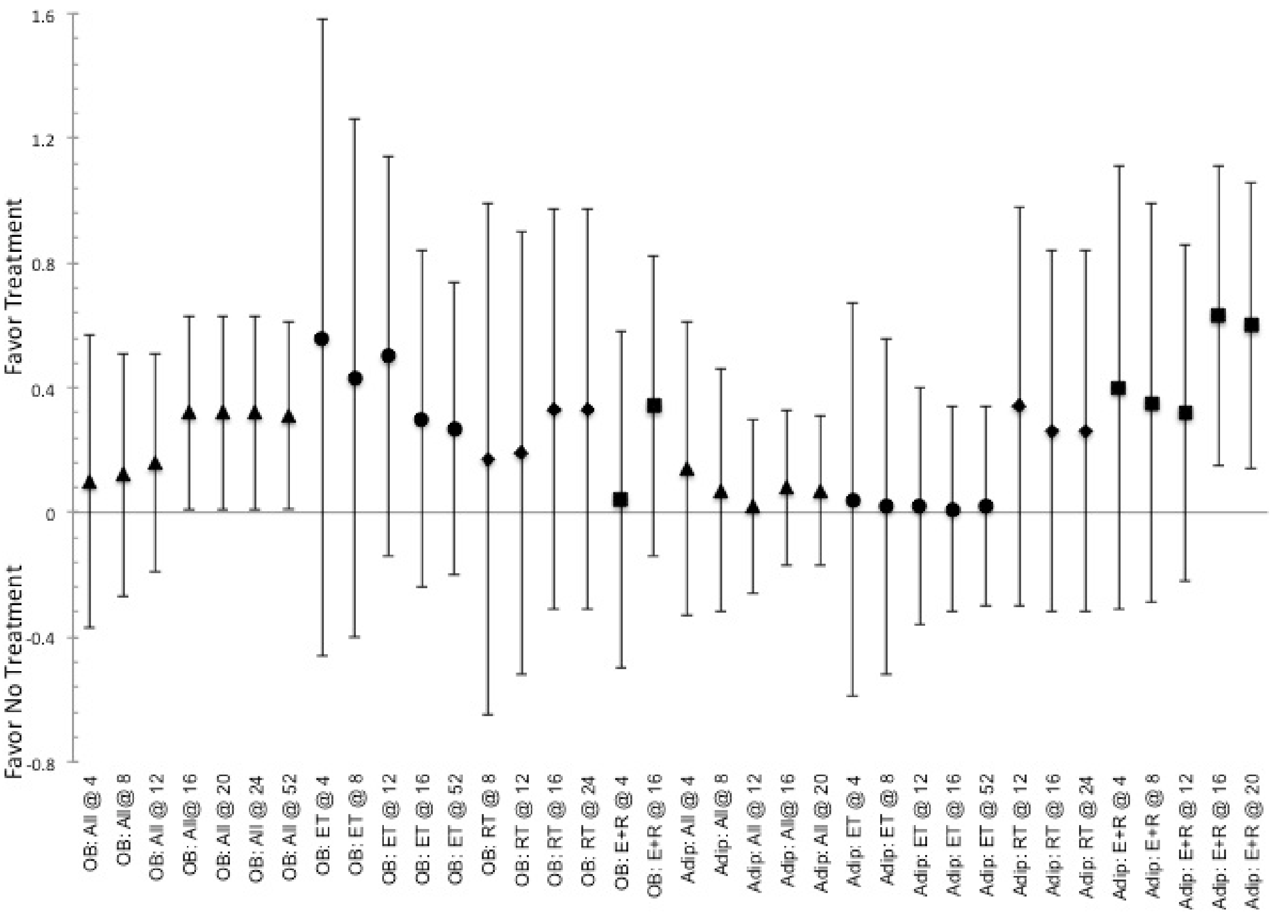

FIG. 2. Indicated pooled ES and $CI_{.95}$ for effective to elicit responses for altering adipokines (leptin, OB, and adiponectin, Adip) associated with health issues related to overfatness obtained from the various training durations (indicated by @ and then number of weeks of training) for the various modes of exercise. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. ET indicated by ●, RT indicated by ♦, E+R indicated by ■, and All Ex indicated by ▲.

Difference in exercise effectiveness by duration

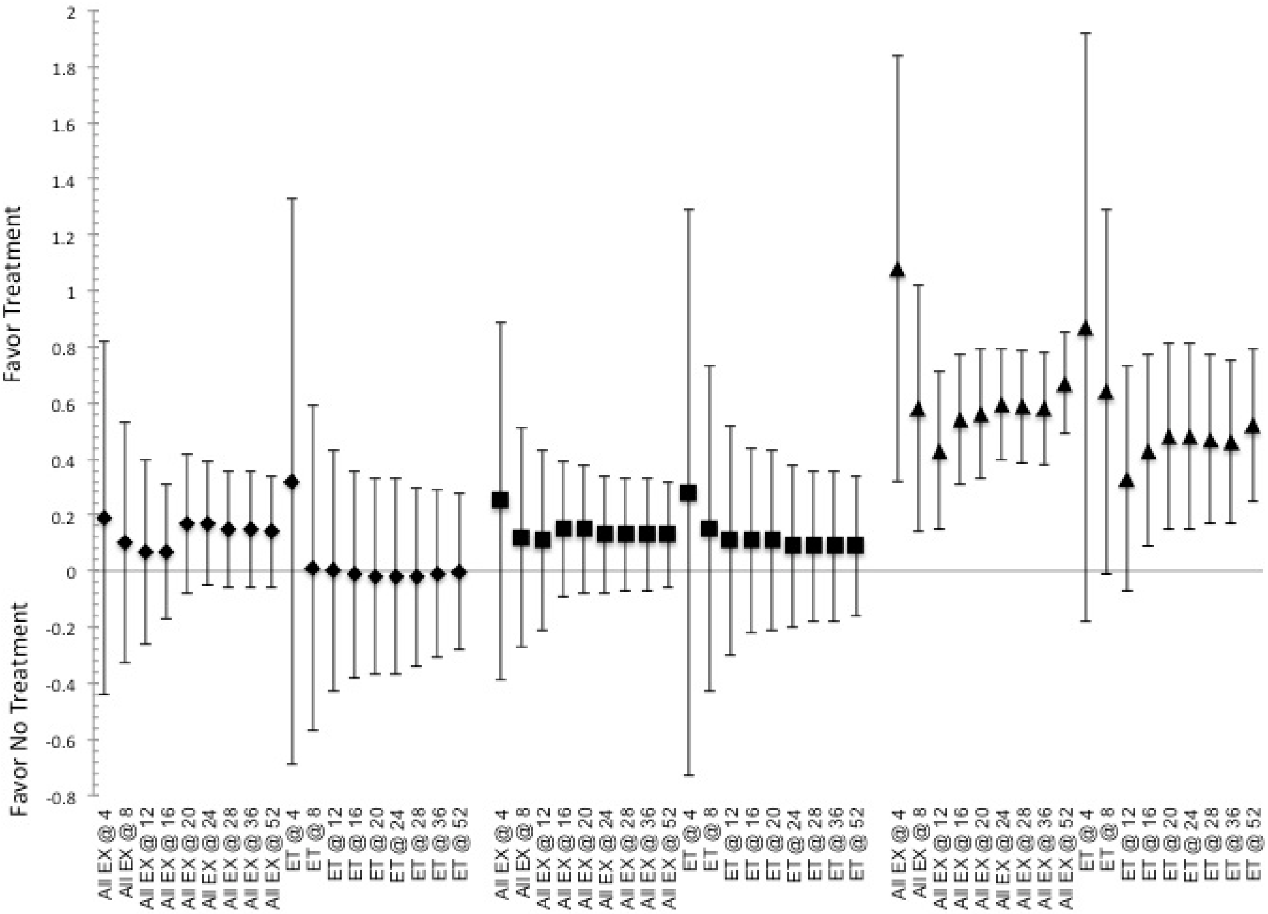

FIG. 3. Indicated pooled ES and $CI_{.95}$ for effective to elicit responses for altering markers of T2DM, fasting insulin, glucose and A1c levels, associated with overfatness obtained following the various training durations (indicated by @ and then number of weeks of training) for all exercise (ALL Ex) or endurance training ET. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. Note that ♦ indicates Insulin, ■ indicates glucose and ▲ indicates A1c.

The comparison between methods, see table 1, indicates that E+R and ET were more effective than RT for altering BM at moderate durations (24-36 weeks). RT is more effective than both ET and E+R at altering FM at 9-15 weeks and 24-36 weeks of training. Additionally, RT was more effective than ET at altering FFM at training duration ≤ 8-weeks, 0.27 (0.01, 0.53), and at 52-weeks, 0.44 (0.04, 0.84), but shows no absolute difference (i.e. $CI_{.95}$ crosses ES=0) in effectiveness relative to E+R for effectiveness at altering FFM. Furthermore, E+R does not show any absolute difference (i.e. $CI_{.95}$ crosses ES=0) relative to ET alone for effectiveness at altering FFM. In addition to changes in body composition, the effectiveness for altering BMI following exercise indicates that ET and E+R is more effective than RT at 24-36 weeks, whereas E+R appears more effective than either ET or RT at 16-23 weeks of continuous training, yet RT is more effective than ET at 52-weeks, 0.54 (0.09, 0.99), table 1.

Effectiveness related to changes in cytokines associated with health status

There appears to be little overall difference in the ES for altering cytokines associated with overfatness (e.g., leptin, adiponectin, IL-6, CRP, TNF- α) between the methods of exercise relative to the duration of training. Where each method of exercise indicates that a short-to-moderate duration of training, i.e. ≤23-weeks, is more effective relative to the longer durations of training. Within the ability to elicit changes in leptin or adiponectin, figure 2, RT appears to be more effective than ET and E+R at 16-23 weeks of training and E+R at ≤8-weeks of training for altering adiponectin, only. RT also appears to be more effective than ET, or E+R, for altering TNF-α levels at 9-15 weeks, supplemental figure 3. Moreover, RT was the only method of exercise to indicate differences between durations for altering leptin levels, where durations of ≤8-weeks was more effective than 16-23 weeks of training, 0.56 (0.04, 1.08). Unlike RT, ET and E+R indicated differences in effectiveness based on the duration of training for altering adiponectin, as each were more effective at 16-23 weeks than at 9-15 weeks of training, 0.95 (0.62, 1.28) and 1.55 (1.01, 2.09) for ET and E+R respectively. Further E+R shows that a training duration of 16-23 weeks of training was more effective than any of the other training durations, 1.55 (1.03, 2.08) for altering adiponectin. Yet the duration of 9-15 weeks of training was the least effective relative to than any of the other training durations,

-0.64 (-1.00, -0.16); especially when compared to the duration of ≤8-weeks of training, where the shortest duration is favored, 0.93 (0.37, 1.49). Additionally, no differences in effectiveness were seen in any of the methods of exercise (ET, RT, or E+R) to alter IL-6 based on the duration of training, supplemental figure 3. While on a limited basis for comparison, due to limited reports, RT at 9-15 weeks indicates being more effective than ≤8-weeks for altering CRP levels, 0.99 (0.12, 1.86), while ≤8-weeks is more effective than 16-23 weeks of training for altering TNF-α, 0.59 (0.06, 1.12), supplemental figure 3. Lastly, for exercise in general a training duration ≤8 weeks is more effective 24-36 weeks, 0.99 (0.37, 1.61), for altering TNF-α.

Effectiveness related to changes in markers of T2DM

Duration of training appears to have limited impact on the effectiveness for the specific type of exercise to elicit changes in the markers for T2DM, e.g. fasting levels of glucose and insulin, figures 3-4. That is except for E+R, where a training duration of 24-36 weeks is more effective than 9-15 weeks, 1.48 (0.36, 2.60) and at the duration of 9-15 weeks being more effective than the duration of 52-weeks, 0.59 (0.14, 1.04), for altering glucose and insulin concentrations respectively.

Even so, differences are noted between exercise based on the durations of training, table 1 and figures 3-4. As the use of RT and E+R are both more effective than ET at durations of 16-23 weeks of training for both altering glucose and insulin levels, table 1. While no other directional selection for effectiveness being noted between the RT and E+R for altering the levels of glucose of insulin, based on the duration of training. Yet E+R is more effective than RT at durations of 9-15 week training but less effective at 16-23 weeks, table 1.

Yet duration may have an impact on the effectiveness to elicit changes in A1c levels, figures 3-4. It appears that longer duration (52-week) of training is less effective than any other time frame, -0.71 (-1.04, -0.38), especially in comparison to training durations of ≤8-weeks, -0.48 (-0.93, -0.02), 9-15 week, -0.67 (-1.15, -0.18), 16-23 weeks, -0.77 (-1.24, -0.38) and the 24-36 weeks, -0.68 (-1.16, -0.20), with moderate durations of 9-15 weeks and 24-36

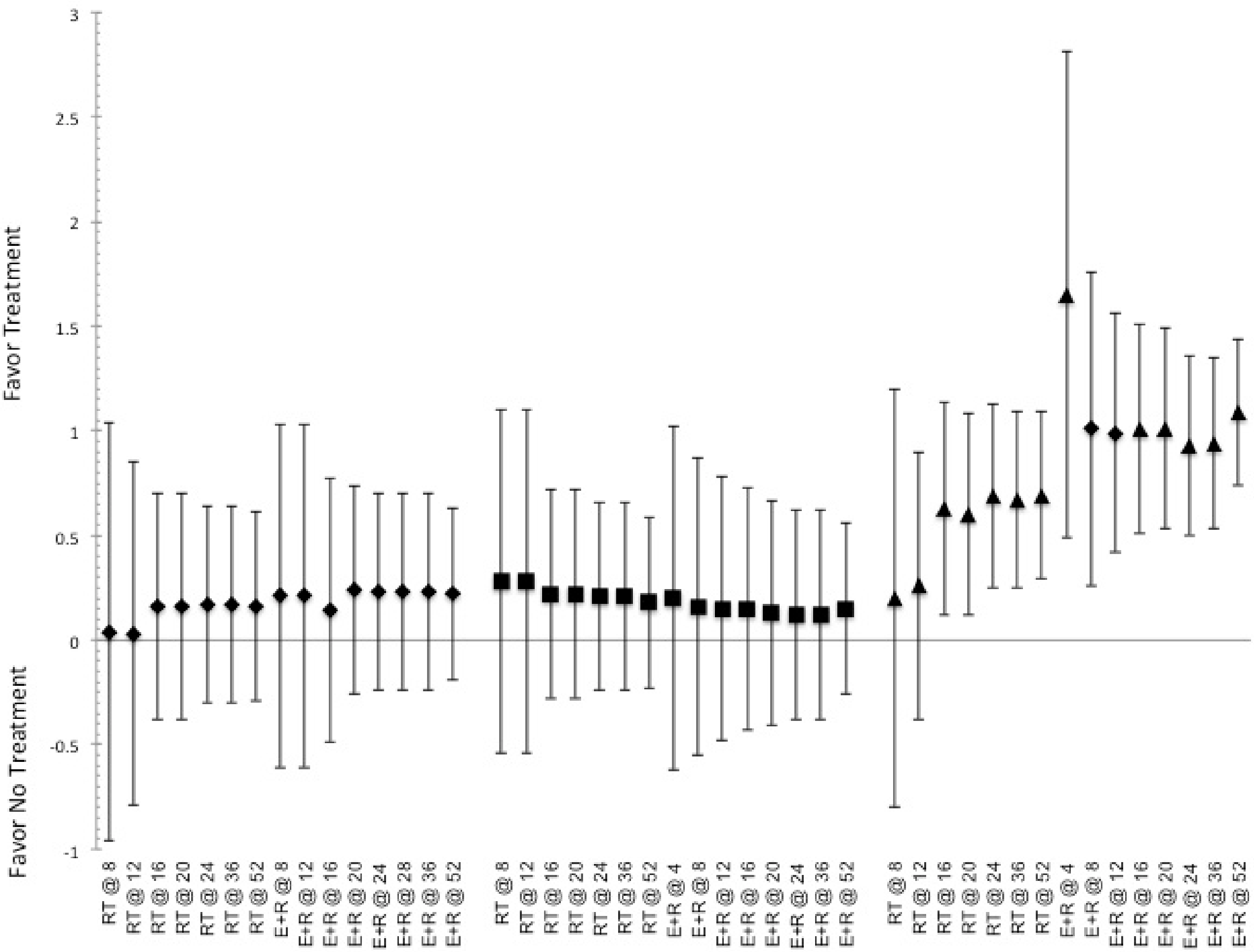

FIG. 4. Indicated pooled ES and $CI_{.95}$ for effectiveness to elicit responses for altering markers of T2DM, fasting insulin, glucose and A1c levels, associated with overfatness elicited within the various training durations (indicated by @ and then number of weeks of training) for resistance training RT or combination of endurance and resistance training E+R. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. Note that ♦ indicates Insulin, ■ indicates glucose and ▲ indicates A1c.

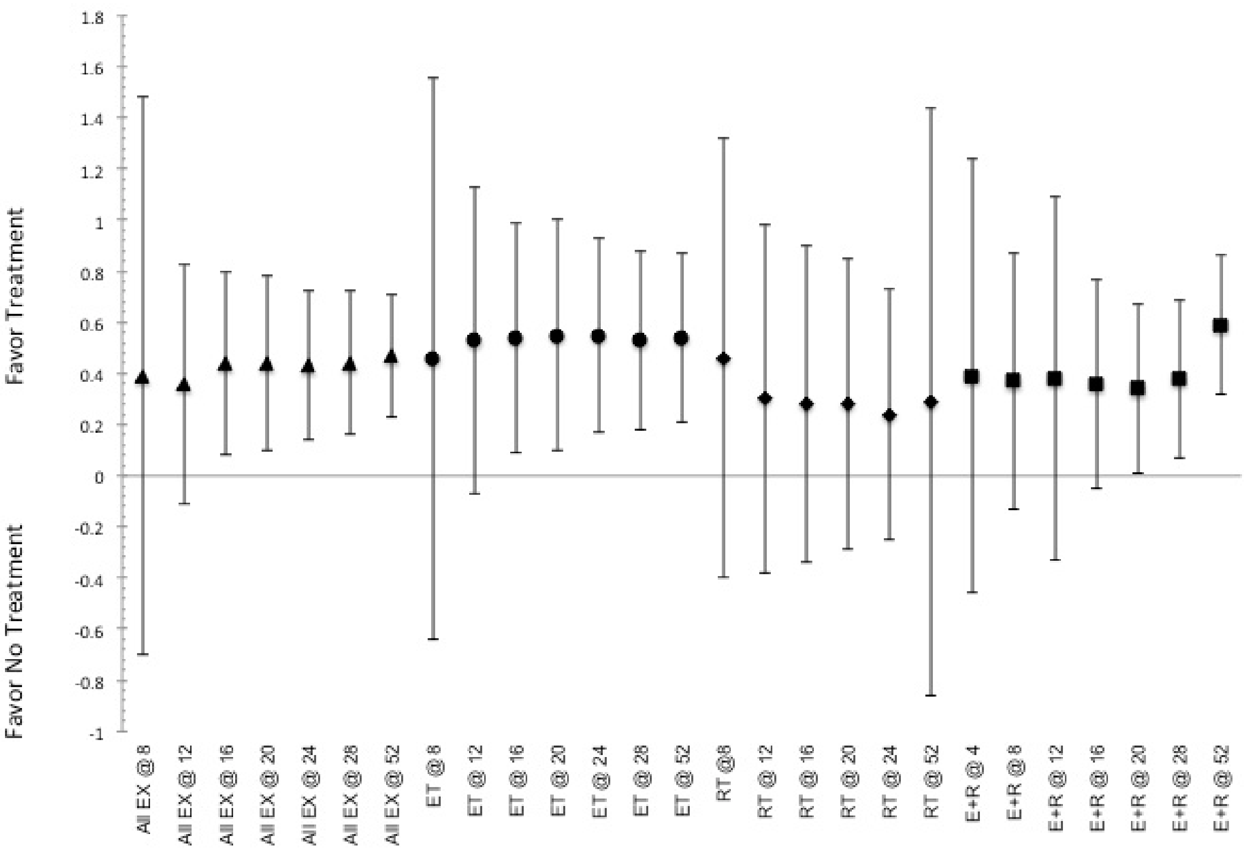

FIG. 5. Indicated pooled ES and CI_{95} for effectiveness to induce improvements in aerobic fitness, VO_2max, based on the various training durations (indicated by @ and then number of weeks of training) of exercise. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. ET indicated by ●, RT indicated by ♦, E+R indicated by ■, and All Ex indicated by ▲.

weeks being the most effective. Based on the method of exercise both ET and E+R indicate having a lower level of effectiveness at 52-weeks of training relative to all other shorter duration training, -0.51 (-0.77, -0.25) and -0.64 (-0.99, -0.29) respectively. Additionally, E+R is more effective than ET at moderate duration (16-23 week) of training, table 1. Whereas, RT at ≤8-weeks and 9-15 weeks are more effective than any of the longer duration studies, 0.46 (0.07, 0.86) and 0.74 (0.33, 1.15) respectively, with a duration ≤8-weeks being more effective than 16-23 weeks, or 52-weeks of training, 1.13 (0.60, 1.66) or 0.90 (0.01, 1.89) respectively, yet 16-23 weeks is less effective than the 52-weeks of training, -0.62 (-1.21, -0.03). Just as RT, E+R indicates that short and moderate durations are more effective than the 52-week duration of training, 0.46 (0.01, 0.99), 0.82 (0.33, 1.31) and 1.13 (0.47, 1.99), for ≤8-weeks, 9-15 weeks and 16-23 weeks respectively and ET indicates being more effective at ≤8-weeks and 9-15 weeks than 52-weeks of training, 0.67 (0.12, 1.12) and 0.52 (0.03, 1.01).

Effectiveness related to ability to alter measures of cardiorespiratory fitness:

There were limited differences in effectiveness related to the changes in cardiovascular measures both between and within the methods of exercise based on the duration, table 1 and supplemental figure 4. Yet, the maximal effectiveness occurs between 8 and 16 weeks of continuous training followed by a plateau in the ES for both ET and RT. In regard to E+R it appears that shorter duration (≤ 8-weeks) training is more effective than moderate to long duration 9-15 weeks, 2.09 (1.08, 3.10) and 1.2 (0.98, 1.92), 16-23 weeks, 1.33 (0.60,1.93) and 1.17 (0.32, 1.90), or 52-weeks, 1.63 (0.48, 2.78) and 0.76 (0.41, 1.11), of training for eliciting changes in SBP and DBP respectively. Furthermore, for SBP, E+R indicated 52-weeks of training being less effective than all other shorter durations, -0.54 (-1.04, -0.06) while training for 9-15 and 16-23 weeks was more effective than any longer duration, 0.55 (0.24, 0.86) and 1.13 (0.82, 1.44) respectively. For ET, where a training duration of 16-23 weeks is the least effective, -0.64 (-1.03, -0.13), relative to all other durations with ≤8-weeks showing the greatest effectiveness relative to the measures at 16-23 weeks of training, 0.50 (0.01, 0.99). For the use of RT the greatest effectiveness occurs at durations of 24-36 weeks of training, 1.13 (0.65, 1.62) versus all other durations while 9-15 weeks is more effective relative to any of the longer durations, 0.55 (0.08,1.02), and specifically to 52-weeks of training, 0.77 (0.06, 1.53).

This pattern was also seen with effectiveness for altering DBP, supplemental figure 4. Where, comparisons within ET responses based on duration show a greater effectiveness at ≤8-weeks of training relative to any other longer training durations, 0.77 (0.43, 1.10), specifically being more effective versus training durations of 9-15 weeks, 1.02 (0.42, 1.86), 16-23 weeks, 1.17 (0.55, 1.92), and 52-weeks, 0.97 (0.15, 1.62). While E+R was less effective at the 9-15 week of training, 1.03 (0.53, 1.53), than any other duration and specifically less effective than the 52-weeks of training, 1.57 (0.85, 2.12). And RT showed greatest effectiveness at the 24-36 week training versus all other durations, 0.52 (0.05, 0.98) and was more effective at ≤8-weeks versus 52-weeks, 0.50 (0.03, 0.97), of training.

Aerobic fitness (VO_{2max}) shows a continuous increase in ES throughout the duration of exercise, figure 5, yet effectiveness appears to be variable based on the duration of exercise, or the type of exercise program utilized, table 1 and figure 8. Exercise in general, only indicates an overall ES favoring for altering VO_{2max} with duration of ≤8-weeks or 52-weeks of exercise intervention, 0.42 (0.00, 0.79) and 0.93 (0.50, 1.33) respectively, within the continuum shorter duration (≤8-weeks) exhibited a greater effectiveness relative to any longer duration, 1.00 (0.44, 1.56), and specifically versus 52-weeks, 1.23 (0.07, 2.30), or 9-15 weeks, 0.91 (0.18, 1.63), of training. As far as within exercise choices, ET is the only exercise that indicates a progressive increase in ES for eliciting changes inVO_{2max}, figure 8, yet no clear evidence for greater ES based on a specific duration of training. While for RT ≤8-weeks of training was more effective than any of the longer duration training, 0.69 (0.29, 1.09), and specifically more effective than 52-weeks, 1.23 (0.80,1.66), or 9-15 weeks, 0.63 (0.15, 1.11) of training and for E+R 52-weeks of training was more effective than either 9-15 weeks, 0.75 (0.36, 1.14), or 16-23 weeks, 0.72 (0.17, 1.27). Comparison between exercise methods show that RT is also more effective than both ET and E+R at duration of ≤8-weeks, table 1 and figure 8, that reverses to the point of indicating no difference in effective as the training duration progresses into longer program designs, table 1.

DISCUSSION

Given the acceptance and recommendation that exercise, or an increase in the level of physical activity (with or without dietary modificaiton), [1,8-10,12,24] while often ignoring the implication that not all exercise or physical activity are equal to each other, can produce positive benefits for any individual who is overfat; it behooves us to assess the impact that acute program variables (e.g., training method and duration) have on the effectiveness in eliciting these reported positive benefits. In particular, it becomes necessary to ascertain the impact and effect (e.g., therapeutic, the alteration of physiological functions, or cheerleader, the small physiological changes and psychological rewards that increase adherence and lead obtaining therapeutic effects) being imparted by exercise within physiological and pathophysiological functions leading to the change in health status of the individual who is overfat. As such, analysis here is a continuation of previous reports on the topic [23] which shows exercise imparts both cheerleader and therapeutic effects, coupling together to allow adaptations in the short duration to encourage the progressive improvement that only occurs from prolonged exposure to exercise ultimately generating the improvements in overall health status expected from exercise.

Within these effects, a continuum of effectiveness for eliciting beneficial responses from exercise develops from both the method and duration of exercise training. Where a lower limit for an effectiveness being completely beneficial, i.e. $CI._{95}$ for ES>0, occurs at 8-weeks of training and an upper limit for continual gain in effect (where a plateau of ES) at 32-weeks of training exist for any type of exercise exposure. Thus indicating that the duration of the exposure to stimulus from exercise is a factor for inducing changes not only in morphology, but also in the overall health status of the individual who is overfat. With the implication for a delay in the onset of effectiveness for inducing modifications from exercise that will also reach a point where no further benefit is achievable. Something to take into account not only when developing the short-term and long-term goals for exercise, but also in establishing the timing for when to modify the training stimulus within a continuous training regimen.

Furthermore, the implications for the timing of initial differences in effectiveness may help shed some light on why previous reports have indicated no difference between exercise methods in treating health issued for individuals who are overfat [24, 42, 114, 115]. As the delay in a distinct type of exercise exhibiting greater effectiveness versus other methods of exercise does not become evident until at least 8-weeks of continuous training is within the time frame that these reports are indicating for study durations. Thus the implication that any exercise has equal benefit is partially corrupted, as training durations being compared could simply be too short to have differences seen, rather than an implication and recommendation that equality between methods of exercise truly exists. Additionally, the continuum of responsiveness here indicates differences in effectiveness for the eliciting changes in various measures of interest are both duration and exercise dependent. Supporting the idea of a continuum of effectiveness noted previously for exercise (with and without diet modification) due to the level of muscle stimulation, without regard to duration [23]. And provides support to the idea of variability within responses that are due to the complex interactions between a multitude of factors, where exercise is one of a number of regulatory factors, in developing and resolving the diseased health status affecting the individual who is overfat [2, 8, 14].

As we parse through this continuum a distinct, and slightly perplexing, trend arises in relation to the difference in effectiveness previously noted as well as to the readily recommended methods of exercise, e.g., endurance (aerobic) or lower-intensity training, for the individual who is overfat to utilize [3, 6, 11, 23, 116-118]. Where after 8-weeks of continuous training, RT exhibits a greater effectiveness than ET across all measures of interest, with the exception of SBP and VO_{2max}, and indicates limited differences to the responses elicited from E+R, with the exception of RT being more effective for altering positive changes in fat-free mass within overall body composition. Interestingly, given the dominance of recommendation, ET appears to have an effectiveness that favors not preforming that type of exercise as the duration of training progresses past 16-weeks of training for altering insulin concentrations. A finding that hints to difference in the metabolic stimulus between RT versus ET, or E+R, leading to the difference in responses and deserves much more attention [2, 14].

This conflict with the readily recommended method of exercise, i.e. reliance on ET [11, 117, 119], for individuals who are overfat, or susceptible to metabolic issues, may begin to help to explain why there is such low attrition for programs previously recommended and prescribed [13, 14]. As the effectiveness to alter outcome measures are not matching the implied desires for responses, or the goals developed, for the individual based on the recommendations for using exercise, i.e. ET, that does not provide the sufficient level of stimulus to effectively induce the desired outcome [2,14,23,26,120, 121]. However, the underlying physiological rationale for the implication of the total training stimulus intensity has on the responses to exercise from individuals who are overfat is incomplete, and deserves much more research. In particular, understanding of how the training stimulus provided from RT instills differences in effectiveness, beyond a moderate duration of training not provided from either ET or E+R [23, 115, 118]. Which is especially important given that we need to have a prolonged engagement with exercise to instill constant improvements in health status of the individual who is overfat.

Although there are trends in conflict with previous reports, some trends support the connotation to the previously touted choice for ET as the selected method of exercise [7, 11, 26, 117-122]. Specifically related to its effectiveness for altering aerobic fitness (VO_{2max}), a finding that might be due to the ET induced alterations in adipose metabolism and the subsequent changes in hormonal and metabolite signals [59, 119, 122-124]. Moreover, while ET indicates being more effective than RT, it shows a high degree of similarity in effectiveness relative to E+R. With the differences between all of the training methods only seen early in training that wane as the duration of training progresses in length. Therefore, indicating that the alteration in acute metabolic responses to the exposure of ET do not occur until later in the duration of training from the inclusion of RT within the exercise training regimen [59,119,122-124]. The indication of difference also supports a contention [26] that E+R maybe more effective than either RT or ET alone, as E+R could possibly provide a combination of the stimulus that may induce acute changes similar to ET that do not exist for RT until the exercise duration becomes prolonged. In which E+R may be inducing a metabolic stress that are in fact different from RT or ET, based on the intensity and duration of exercise, an issue that deserves more attention in future research, yet additional speculation falls outside the scope of this analysis.

Nonetheless, the differences indicated here are most likely the results of linking modifications in metabolic state and cardiovascular fitness to the ability to effectively alter inflammatory biomarkers associated with overfatness. As modifications develop through the combination of these cytokines coupled with the difference in the metabolic and mechanical stimulus provided by exercise impacts the overall level of response [8, 23, 112, 125, 126]. Where the trend for effectiveness continues to show agreement with a previous discussion related to the importance of inclusion of RT, while also showing disagreement with recent reviews touting the use of E+R versus either ET or RT [23, 26, 42, 115, 125, 126]. In addition to this agreement, the comparison between the types of exercise show that both RT and E+R are more effective than ET, yet show no difference between each other at the various durations examined. An implication which would mean while seeing differential cardiorespiratory responses absolutely is due to the overall duration of training, the level of effectiveness to elicit the response supports the indication for the importance of the stimulus of training [23]. Yet, just as with the indication of differences in altering aerobic fitness and metabolism the interactions are an issue that needs further investigation.

Notwithstanding the number of questions remaining unanswered regarding the underlying physiological differences between methods of exercise, indications from the findings here allow extrapolation to the designing and developing of exercise programs. Most important is an indication of effectiveness waning as training becomes prolonged, especially when compared to shorter and moderate duration training regimens. Thus, indicating that the differences in absolute values that may support the use of longer duration training programs may simply be the indication of total time being a factor in establishing absolute differences, not for the overall effectiveness. Which is interesting given the desire that exercise becomes a continued pattern of behavior throughout life for improved health [5, 8]. However, if you were to couple the impact that shorter duration training has to overall effectiveness, i.e. utilize intermittent and varying intensities of training through a periodization of the exercise program, with the prolonged use of exercise we may be able to maximize the overall impact that exercise can have within a treatment regimen.

From the perspective of coupling the shorter duration effectiveness over the long duration use of exercise, a series of recommendations are available to establish a periodization of exercise in the treatment of health issues for the individual who is overfat. First, given the peak time for greatest effectiveness, training programs may be best when designed around a blocked-periodized schedule of 4-to-12-week durations, using a schedule of 3 days of RT and 3-4 days ET per 7-day training week. Second, when developing exercise prescriptions RT is highly recommended for use as the principal form of exercise utilized intermittently in shorter durations, e.g., 4 to 8 weeks, or through a concurrent pattern of exercise with ET in both shorter and moderate duration regimens. With the training intensity of RT being most effective when utilizing a level of exercise stimulus associated with muscle hypertrophy (e.g., >75% 1RM at a training volume of 3-sets of 10-repetitions with 60-seconds of rest) [23]. While ET should be rarely implemented alone, and when utilized should be incorporated into a training regimen through a combination of concurrent training with RT for short to moderate durations of training, i.e. 8-to-12 weeks, at the previously indicated [23] levels for greatest effectiveness (e.g., intervals of variable intensities for 30-40 minutes, or continuously at a heart rate intensity >75% HR_{max} (VO_{2max}) for 40-60 minutes). Yet more investigation into the patterning and programming of periodized exercise for individuals who are overfat is necessary before these recommendations can become definitive, especially related to the impact of the method (e.g., linear, blocked, or undulating) for periodization on physiological responses seen within the mesocycle and the macrocycle development of the periodized training regimen.

Furthermore, understanding the pattern of effectiveness based on the duration of training also allows for the establishment of properly organized and segmented goals, e.g., short-term, moderate-term, and long-term goals. Which is ever important, as there is the given need to have a psychological attraction to, and reward for completing, the individual exercise session that eventually allows for long-term positive adaptations in health status to develop for the individual who is overfat. While it may be true that body compositional changes are a key cheerleader effect to continuation of exercise for individuals who are overfat reliance on body composition early can be a hindrance to comply with using exercise. This may be due to the apparent delay in the onset of effectiveness, at least 8-weeks before $CI_{.95}$ of ES is always >0.00, and the over-reliance on such modifications, in the short-term, where the inability to meet unrealistic goals may be detrimental to the psychological adherence necessary for continual application of exercise. Thereby, short-term (<8-weeks) goals reflect behavior changes, i.e. finding a “workout partner” or “getting into the gym”, and performance gains, i.e. increase in strength or endurance measures for a given exercise or pattern of activity, more than improvements in either body composition or health status. As these changes in behavior and performance will act as the cheerleader effects necessary early in any behavior intervention that leads to the continuation in the intervention, e.g., exercise, when self-selection for continuation is required. Stemming from these performance goals should be moderate-term (8-12 week) and long-term (i.e. >12-week) goals related to modifications in outcome measures, e.g., changes in body composition, diabetic indices, aerobic fitness, that should be reachable within a beneficial therapeutic effect (i.e. favoring use of treatment). Additionally, intermediate goals should be a reflection of a combination of performance, body compositional and health status modifications that are necessary to ensure the continual use of exercise throughout the lifetime of the individual.

Even with these implications and indications, the ability to formally aver these statements is limited. Namely, the formalization of these implications is limited by the current state of publication bias toward reporting only positive findings along with any study published after the end of inclusion and beginning of analysis. Secondly, limitations to the over-arching similarity of exercise prescription utilized and responses from participants in the various studies included within the analysis here. Thirdly, while the general rule for meta-analysis and regression analysis is to examine random-controlled studies only, a methodological hindrance in blinding subjects to use of exercise studies for human participants exists and therefore studies analyzed here included observational, tracking and peer-grouped controlled studies along with the random-controlled studies. To combat these limitations, analysis was performed based on the assumption of random-effect in all calculations. However, even the use of the assumption for random-effect will not eliminate all limitations to this study and therefore, we must continue to review and analyze findings on a pooled-effect to further ascertain the level of effectiveness that different methods of exercise acts to elicit beneficial effect for individuals who are overfat. Additionally, the implications for training intensities and development of periodization of training for individuals who are overfat has gone completely unanswered, outside of this report and earlier from this author and leaves a large hole in the body of knowledge to fill if we wish to continue to stipulate the use of exercise in the medical treatment of overfatness.

CONCLUSIONS

Analysis of effectiveness based on the duration of exercise training indicates a continuum of effectiveness for both the type of exercise and the overall duration of training. In which exercise does not provide an overall level of beneficial effect (i.e. $CI_{.95}$ of ES not including 0.00) until the completion of at least 8-weeks of continuous training. And where differences between types of exercise do not become evident until 8-weeks for changes in body morphology and 12-weeks for modifying measures of either cardiorespiratory or metabolic characteristics. As such, it needs to be stressed that for individuals who are overfat even with anecdotal reports for rapid results from the inclusion of exercise, the effectiveness of exercise for eliciting modifications in both body composition and health status may in fact be a delayed. From which it is possible to make distinct clinical recommendations. First, early goals must focus on behavioral changes and performance (e.g., starting the pattern of exercise, making improvements in the within session training intensities) modifications versus clinical (e.g., morphological, or cardiovascular and metabolic fitness) modifications early in treatment. While clinical modification becomes important for goal setting once training has become prolonged. Secondly, since the beneficial effectiveness of exercise wanes over time, where we see differences in effectiveness at very short durations that plateaus as durations become longer that parallels the reduction in the difference of effectiveness between the methods of exercise as the duration of the training reaches prolonged duration periods of continuous training. Specifically, the waning of effectiveness indicates that 32-weeks of continuous training may be a point where adaptations of benefit have been optimally reached. As such, long-term exercise regimens must be periodized so as to maximize the short-term benefits while minimizing the impact that the 32-week plateau has on continued effectiveness and responses to exercise.

When parsed into the distinct methods of exercise, there is an indication of differences between the methods of exercise within these continuums of effectiveness based on duration. In which RT, or E+R, is more effective for eliciting beneficial alterations to measures of body composition (e.g., FM and FFM), DBP, markers of inflammation and T2DM than ET across the various timeframes. With the greatest difference between methods of exercise seen at shorter and moderate duration lengths of training (8-to-24 weeks in duration). While ET is more effective at altering SBP and VO_2 than RT or E+R and equally effective for altering BM, only seen at longer duration lengths of training (>24-weeks in duration). Furthermore, even though recently touted for greater effectiveness, E+R appears to have little difference in overall effectiveness related to the changing the measures of interest in comparison to that of either RT or ET based on the duration of training.

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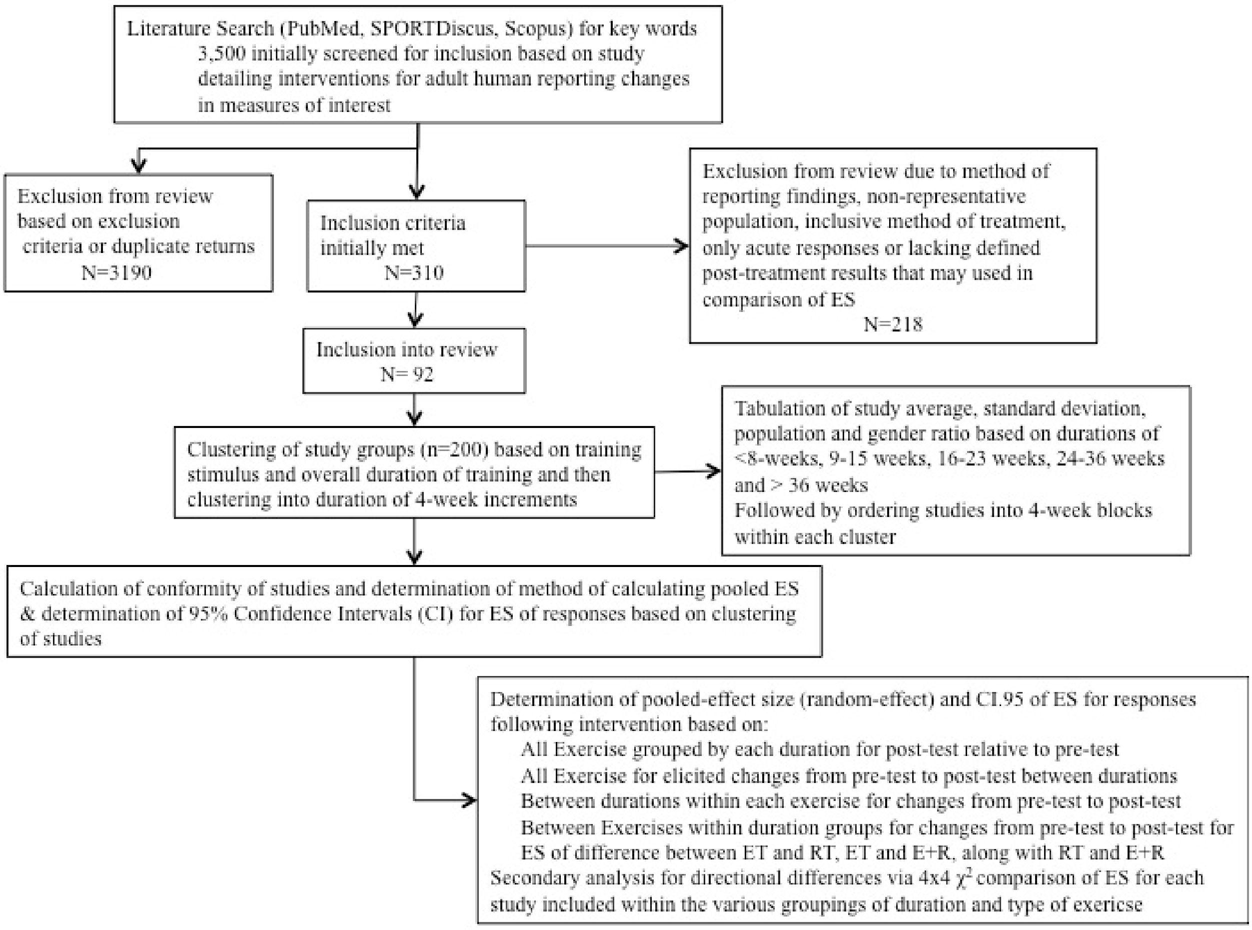
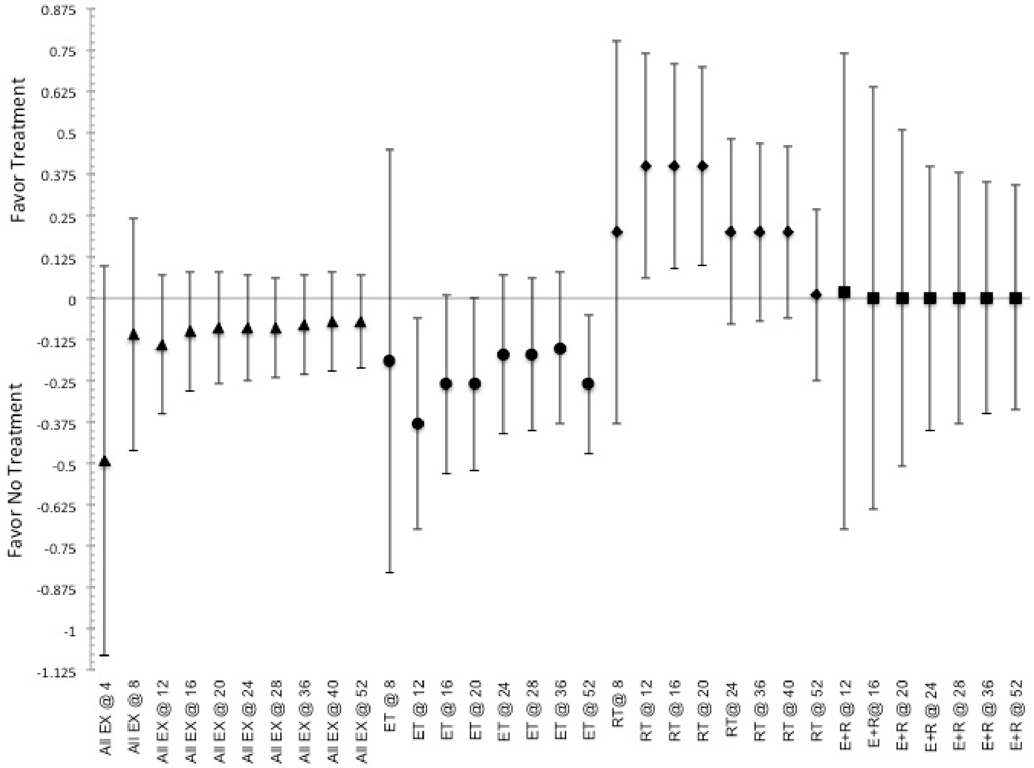
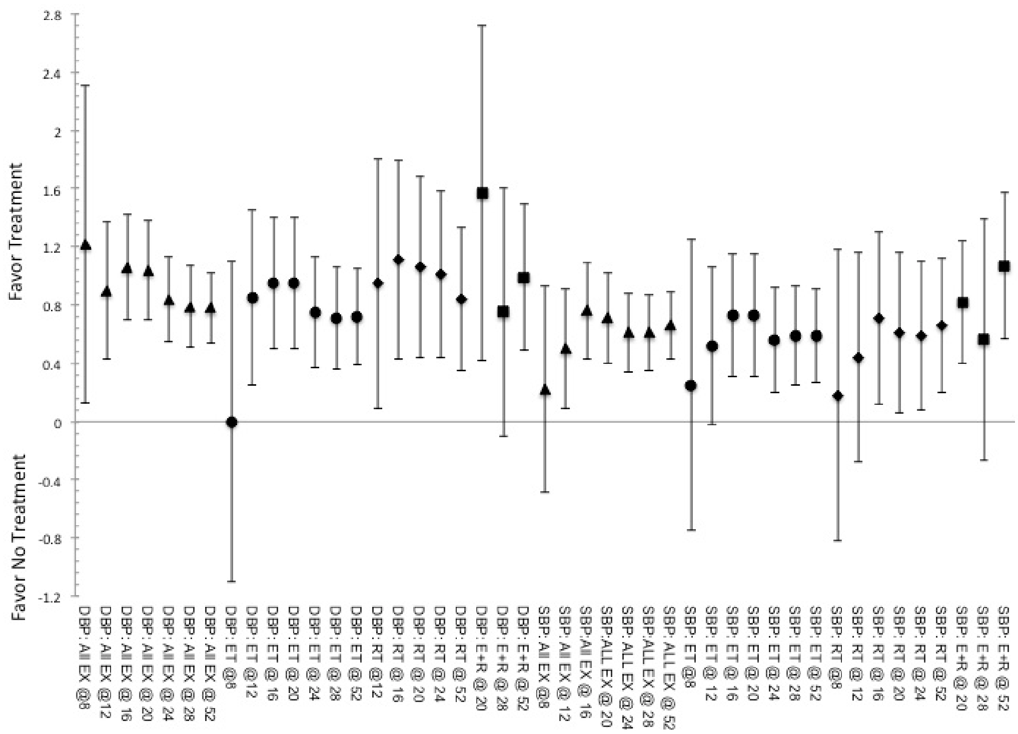
Supplemental figures



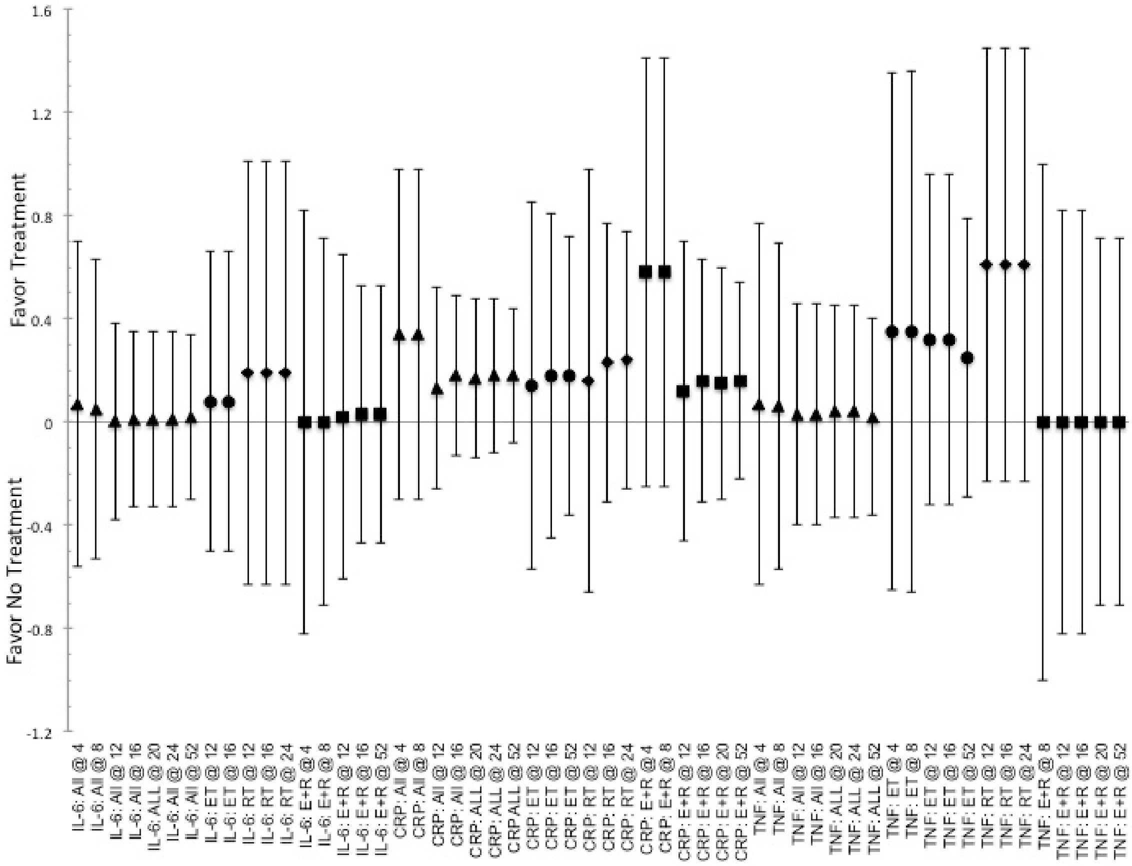
SUPPLEMENTAL FIG. 1. Summary of the evaluation methods and search engine returns of studies leading to the inclusion and subsequent meta-analysis based on the PRISMA checklist.



SUPPLEMENTAL FIG. 2. Indicated pooled ES and CI.95 for effective to elicit responses in measures of body morphology (fat-free mass) for the various training duration utilized (indicated by @ and then number of weeks of training) for the exercise stimuli. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. ET indicated by ●, RT indicated by ♦, E+R indicated by ■, and All Ex indicated by ▲.



SUPPLEMENTAL FIG. 3. Indicated pooled ES and CI.95 for effective to elicit responses for altering cytokines (C-reactive protein as CRP, interleukin-6 as IL-6 and tumor necrotic factor-α as TNF-α) associated with health issues related to overfatness based on the various training durations (indicated by @ and then number of weeks of training) for the stimulus from the various modes of exercise. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. ET indicated by ●, RT indicated by ♦, E+R indicated by ■, and All Ex indicated by ▲.



SUPPLEMENTAL FIG. 4. Indicated pooled ES and CI.95 for effectiveness to elicit responses in measures of cardiovascular function, systolic (SBP) and diastolic (DBP) blood pressures, obtained based on the various training durations (indicated by @ and then number of weeks of training) for the stimulus of exercise. Indication of a positive ES shows favor for the use of intervention, while negative ES shows favor toward not utilizing said intervention. ET indicated by ●, RT indicated by ♦, E+R indicated by ■, and All Ex indicated by ▲.

SUPPLEMENTAL TABLE 1. Studies utilized for analysis of differences in effectiveness for eliciting alternations in measures of interest based on the duration of training and the modality of exercise.

Study	Exercise & Duration of Intervention	Summary Description of Exercise	Measures of Interest for comparison
		≤ 8-weeks	
Ahmadi* [27]	ET: 5x's/wk for 4-wk	ET‡: cycle 40 min/session @ 50-60% VO_{2max} for 5 sessions/wk	Morph, Adip, T2DM
Ara [28]	RT: 3x's/wk for 6-wk	RT‡: 1-3 x 3-12 @ Progressive 1RM (range 50-90%) for Squats, Leg Press, Leg Curl/Ext, Hip Flexion w/ 90 s rest @ total expenditure of 220-300 kcal/session	Morph, Ob
Ballor [29]	RT: 3x's/wk for 8-wk	RT: 3x10-12 @ 10RM for: Chest Press, Leg Press, Lateral Pull-down, Arm Curl/Ext, Leg Curl/Ext, Calf Raise	Morph
Boudou [30]	ET: 3x's/wk for 8-wk	ET: 2-sessions continuous @ 45-min/session @ 75% VO_{2peak}, 1-session interval @ 5x2-min @85% VO_{2peak}, 3-min rest interval @ 50% VO_{2peak}	Morph, Ob, Adip
Fisher [31]	ET or RT: 3x's/wk for 8-wk	ET‡: 20-40 min @ 65-80% MHR (progressive) RT‡: 1-2x10 @ 60-80% 1RM (progressive) for Leg Press, Squats, Leg Ext/Curl, Arm Curl, Lateral Pull-down, Bench Press, Military Press, Trunk Exercises	CRP, Il-6, TNF-a
Halle [32]	ET: Daily for 4-wk	ET‡: 5-session/wk @30-min/session @ 70% HR_{max}, 2-sessions/wk general PA @ self-selected intensity & duration	Morph, Ob, Adip
Hallsworth [33]	ET: 3x's/wk for 8-wk	RT: 3 set of 8-exercise CRT @ unknown repetition for bicep curl, calf press, triceps press, chest press, hamstring curl, shoulder press, leg extension, lateral pull-down @ 50-70% 1RM (progressive) with unknown rest interval	Morph, T2DM
Hammer [34]	ET: 5x's/wk for 6-wk	ET‡: distance of 1.6-4.8 km/session (progressive) @ 60-85% HRM (progressive)	Morph, T2DM
Hansen* [35]	ET: 3x's/wk for 8-wk	ET: 55-min/session @ 50%VO_{2peak} on ergometer OR 40-min/session @ 75% VO_{2peak} on ergometer with training equivalent energetics (1.3±0.05 MJ/session)	Morph, VO_2, Met S
Hill [36]	ET: Daily for 5-wk	ET‡: distance of 1.6-5.6 km/session (progressive) @ unknown intensity	Morph
Ishii [37]	ET: 5x's/wk for 6-wk	ET‡: 60-min/session @ 50% VO_{2max} (adjusted intensity per week)	Morph, Ob, VO_2
Kanaley [38]	RT: 3x's/wk for 6-wk	RT: 3 sets x 8-12 reps @ 80% 1RM (progressive) for chest press, leg press, shoulder press, lateral pull-down, leg extension, leg curl, bicep curl, triceps press-down, abdominal exercise (3x15)	Morph, Ob
Kempen [39]	ET: 3x's/wk for 8-wk	ET‡: 90-min group exercise sessions @ 50-60% VO_{2max}	Morph
Lucotti [40]	ET or E+R: 5x's/wk for 4-wk	ET‡: 15-min rowing erg/session; 15-min cycle erg/session @ 70% $APHR_{max}$ E+R‡: 45-min/session with RT @1 set x 10 rep (for arm curls, military press, push-ups, upright row, back extension) & 1 set x 20 rep (for squats, knee extensions, heel raises, bent-knee sit-ups) 40-50% 1RM with rest < 60 sec between exercises and ET: 15-min rowing erg/session; 15-min cycle erg/session @ 70% $APHR_{max}$	Morph, Ob, Adip, CRP, TNF-α, SBP, DBP, VO_2
Maiorana [41]	E+R: 3x's/wk for 8-wk	E+R: CRT for RT @ 45 s of RT @ 55-65 % MVC (progressive) w/ 15 s rest between RT followed by 5-min ET @ 70-85 % PHR (progressive) intermittent to RT-exercises	Morph, Ob, Adip, VO_2
Ng [42] [2]	ET or RT: 2-3x's/wk for 8-wks	ET & RT equated to 3.5 METs per session per exercise ET‡: 50-min/session ergometer @ 65-70% $APHR_{max}$ (progressive) RT‡: CRT 3-circuits of 1x10 for leg press, leg raises, hamstring curls, bicep curls, triceps extension, anterior shoulder raises, lateral shoulder raises, hip abduction, hip extension @ 65-70% 1RM (progressive), unknown rest	Morph, SBP, DBP, VO_2
Oberbach [43]	ET: 4x's/wk for 4-wks	ET: 3-days: 60-min unknown intensity (20-min calisthenics/20-min steady state/20-min "power-training" & 1-day: 60-min swimming	Morph, Adip, OB, Il-6, CRP

Note: Morph indicates any measure of body morphology/composition (e.g., body mass, fat mass or fat-free mass) and T2DM (e.g., fasting levels of glucose, insulin or HbA1c); and D indicates a dietary component to the intervention. All other abbreviations are noted within the list of abbreviations and generally agreed upon abbreviations for hormones. * Indicates study has data for analysis at multiple time points. +Indicates some results mirror previous reports from author and only utilized once within a time period for analysis. ‡Indicates a hypocaloric, or diabetic/low carbohydrate, dietary intervention used in conjunction with exercise.

SUPPLEMENTAL TABLE 1 CONTINUED. Studies utilized for analysis of differences in effectiveness for eliciting alternations in measures of interest based on the duration of training and the modality of exercise.

Study	Exercise & Duration of Intervention	Summary Description of Exercise	Measures of Interest for comparison
Tokmakidis* [44]	E+R: 4x's/wk (2 ET, 2 RT) for 4-wk	ET: 40-45 min/session treadmill @ 60-80% HR_{max} (progressive) RT: 3 set x 12 rep @ 60% 1RM for bench press, seated row, leg extension, lateral pull-down, pec-deck, leg curl and 45-60 sec rest per set and 180-240 sec rest per exercise	Morph, T2DM
Touvra [45]	E+R: 4x's/wk for 8-wk	ET: 30 min/session @ 70-80% HR_{max} RT: 3 set x 15 rep for leg press, knee extension, abduction, bench press, pec-deck, rows@ 60% 1RM with 60-sec rest between set and 120-sec between exercise	Morph, CRP, TNF-α, Il-6
		9-15 Weeks	
Ahmadizad [46]	ET or RT: 3x's/wk for 12-wk	ET: 75–85% of MHR for 20-30-min (progressive), RT: 4x12 CRT of 11 exercises @ 50–60% 1RM	Morph, Adip
Ballor [47]	ET or RT: 3x's/wk for 12-wk	ET: 50% VO_{2max} x 20-60 min (progressive) RT: 3x8 @ 50-80% 1RM (progressive) Squat, Bench, Leg Ext/Curl, Arm Ext/Curl, Lateral Pulldown	Morph, SBP, DBP, VO_2
Bouchard [48]	RT: 3x's/wk for 12-wk	RT‡: 3x8 @ 80% 1RM for (leg press, chest press, leg extension, shoulder press, sit-up, seated row, triceps extension, arm curl, and calf extension) w/ 60-90 s rest	Morph
Bryner [49]	ET: 4x's/wk RT: 3x's/wk for 12-wk	ET‡: 20-60 min (progressive) @ self-paced RT‡: 2-4x15-12 @ 15RM-to-8-RM (progressive) for 10-exercise CRT w/ 60-s rest	Morph
Bweir [50]	RT: 3x's/wk for 10-wk	ET: 20-30-min/session (progressive) @ 60-75% HR_{max} RT: 3 set x 8-10 rep 7-exercise CRT knee and hip flexion/extension, hip abduction/adduction, elbow flexion/extension, chest press @ unknown intensity with 120-sec rest intervals	Morph, T2DM
Christiansen [51]	ET: 3x's/wk for 12-wk	ET‡: 60-75 min @ unknown intensity to equate to 500-600 kcal/session	Morph, Ob, Adip, Il-6, TNF-α, SBP, DBP, VO_2
Donnelly [52]	ET, RT, or E+R: 4x's/wk for 12-wk	ET‡: 20-60 min (progressive) @ 70% HRR RT‡: 2-3 x 6-8 @ 70-80% 1RM (progressive) on CRT exercises unknown, rest unknown	Morph, VO_2
Donnelly [53]	RT: 3x's/wk for 12-wk	RT‡: 3 sets 8,6,6 @ 70% 1RM, progress to 4 sets 8.6.6.4 @ 80% 1RM for Bench Press, Latissimus Pull-down, Leg Ext/Curl, Shoulder Press, Arm Pullover, Arm Curl/Ext	Morph, VO_2
Giannopoulou [54]	ET: 3x's/wk for 14-wk	ET‡: 50-min/session @ 65-70% VO_{2peak} (equated to 250-300 kcal/session)	Morph, VO_2
Hill [55]	ET: 5x's/wk for 12-wk	ET‡: 20-50 min (progressive) @ 60-70% HRM	Morph
Ho [56]	ET, RT, or E+R: 5x's/wk for 12-wks	ET‡: 30-min @ 60% HRR RT‡: 4x12 @ 10RM for Leg Press, Leg Curl/Ext, Bench Press, Seated Row w/ 60 s rest E+R‡: ET for 15-min @ 60% HRR & RT for 2x12 @75%1RM	Morph, Ob, Adip, VO_2
Jorge [57]	ET, RT, or E+R: 3x's/wk for 12-wk	60-min/session: ET: cycle @ LAT RT: unknown volume of CRT for leg press, bench press, lateral pull-down, seated row, shoulder press, abdominal curls, leg flexion @ unknown intensity (%1RM), or rest intervals E+R: cycle @ LAT ½ time & RT @ ½ training volume	Morph, Adip, CRP, TNF-α, SBP, DBP, VO_2
Jung [58]	ET: 5x's/wk for 12-wk	ET: 30-min/session @ >5.3 METs OR 60-min/session @ 3.5-5.2 METs with training equated to 500 kcal/session	Morph
Kadoglou [59]	ET: 4x's/wk for 12-wk	ET: 30-60 min/session (progressive) @ 60-75% HR_{max} (progressive)	Morph, SBP, DBP, VO_2
Kang [60]	ET or E+R: 3x's/wk for 12-wk	ET‡: 60-min/session @ 60% HRR E+R‡: CRT 60-min/session @ 60 % HRR with RT @ 3 set x 12 rep for lateral pull-down, abdominal curls, leg curls, leg extension, bicep curls & ET @ 20-min	Morph, Adip, CRP, VO_2

Note: Morph indicates any measure of body morphology/composition (e.g., body mass, fat mass or fat-free mass) and T2DM (e.g., fasting levels of glucose, insulin or HbA1c); and D indicates a dietary component to the intervention. All other abbreviations are noted within the list of abbreviations and generally agreed upon abbreviations for hormones. * Indicates study has data for analysis at multiple time points. ⁺Indicates some results mirror previous reports from author and only utilized once within a time period for analysis. ‡Indicates a hypocaloric, or diabetic/low carbohydrate, dietary intervention used in conjunction with exercise.

SUPPLEMENTAL TABLE 1 CONTINUED. Studies utilized for analysis of differences in effectiveness for eliciting alternations in measures of interest based on the duration of training and the modality of exercise.

Study	Exercise & Duration of Intervention	Summary Description of Exercise	Measures of Interest for comparison
Kempf [61]	ET: 7x's/wk for 12-wk	ET: 30-min/session of WiiFit Plus program @ self-selected intensity	Morph
Kerksick [62]	E+R: 3x's/wk for 14-wk	E+R: @ HR of 60-80% MHR using CRT of 14 exercises either paired: Arm Ext/Curl, Leg Ext/Curl, Shoulder Press/Lateral Pulldown, Hip Abd/Add, Chest Press/Seated Row, Abdominal Crunch/Back Extension, Shoulder Shrug/Dip; or unpaired: Leg Press, Squat, Pec-Deck, Oblique, Hip Ext, side bends, stepping) x 30 s @ unknown %1RM w/ callisthenic 30 s between sets/paired exercise	Morph
Klimcakova [63]	RT: 3x's/wk for 12-wk	RT‡: 1x12-15 @ 60-70% for 17-exercise CRT	Morph, Ob, Adip, Il-6, TNF-a, CRP, SBP, DBP, VO_2
Kwon [64]	RT: 3x's/wk for 12-wk	RT: 3 sets x 10-15 reps (elastic resistance) @ 40-50% 1RM (equivalent) for bicep curl, triceps extension, upright row, shoulder press, chest press, squat/deadlift, hip flexion, leg flexion, leg extension	Morph, T2DM
Lee [65]	ET: 5x's/wk for 13-wk	ET: 60-min/session @ 60% VO_{2peak}	Morph, VO_2
Moreira [66]	ET: 3x's/wk for 12-wks	ET: 20-60 min (progressive) @ 10% of Anaerobic Threshold Interval ET 20-60 min (progressive) total time @ 2:1 ratio of 120% Anaerobic Threshold to Rest time	Morph
Poirier [67]	ET: 3x's/wk for 12-wk	ET: 30 to 60-min/session (progressive) @ 60% VO_{2peak}	Morph, VO_2
Polak [68]	ET: 5x's/wk for 12-wk	ET: 45-min @ 50-65% VO_{2max} (progressive) for 2x's/wk group exercise class, 3x's/wk cycle ergometer	Morph, Ob, Adip, Il-6, TNF-α, VO_2
Racette [69]	ET: 3x's/wk for 12-wk	ET‡: 35-min @ 65% VO_{2max}	Morph
Schjerve [70]	ET or RT: 3x's/wk for 12-wk	ET: Intervals @ 10-min @ 50-60% MHR followed by 4 cycles of 4-min: 3-min ratio of 85-95% MHR then 50-60% MHR followed by 5-min @ 50-60% MHR, or 47-min @60-70% MHR RT: 4x5 @ 90% 1RM (progressive) for Leg Press or Squats, trunk exercises @ 3x30 w/ 30 s rest	Morph, SBP, DBP, VO_2
Sigal* [71]	ET, RT, or E+R: 3x's/wk for 12-wk	ET‡: 15-min/session @60% HR_{max} & 45-min/session @ 75% HR_{max} RT‡: 2-3 sets x 7-9 reps for 7-whole body exercises @ unknown intensity or rest interval E+R: full version of both ET and RT	Morph, T2DM
Trapp [72]	ET: 3x's/wk for 15-wks	ET: Interval cycle ergometer @ 8-sec sprint: 12-sec recover intervals progress from 5-min to 20-min total time or 10-40 min @ 60% VO_{2peak} (progressive)	Morph, Ob, Adip, VO_2
Wycherley [73]	ET: 4-5x's/wk for 12-wk	ET‡: 25-60 min/session (progressive) @ 60-80% baseline-HR_{max} (progressive)	Morph, SBP, DBP, VO_2
		16-23 weeks	
Cauza [74]	RT or ET: 3x's/wk for 16-wk	ET: 15-90 min/session (progressive @ 5-min/session per week after 4th week) @ 60% VO_{2max} RT: 1-3 sets (progressive) x 10-15 reps @ 10-15RM (progressive) for bench press, shoulder press, chest flies, lateral pull-down, bicep curls, triceps extension, leg press, calf press, leg extension, and abdominal exercises	Morph, SBP, DBP, VO_2
Cuff [75]	ET or E+R: 3x's/wk for 16-wk	E+R: 75-min @ 60-75% HRR w/ RT@ 2x12 for Leg Press, Leg Curl, Hip Ext, Chest Press, Latissimus Pulldown @ unknown intensity or rest ET: 75 min @ 60-75% HRR	Morph, VO_2
De Feyter [76]	E+R: Unknown sessions/wk For 20-wk	ET: Interval @ 4-8 sets (progressive) x 30-sec or 60-sec (50-60% W_{max}) RT: whole body (unknown exercises) @ 2-sets x 10-repetitions @ 50-80% 1 RM (progressive) and unknown rest intervals	Morph, Adip, CRP, TNF-α, SBP, DBP, VO_2

Note: Morph indicates any measure of body morphology/composition (e.g., body mass, fat mass or fat-free mass) and T2DM (e.g., fasting levels of glucose, insulin or HbA1c); and D indicates a dietary component to the intervention. All other abbreviations are noted within the list of abbreviations and generally agreed upon abbreviations for hormones. * Indicates study has data for analysis at multiple time points. +Indicates some results mirror previous reports from author and only utilized once within a time period for analysis. ‡Indicates a hypocaloric, or diabetic/low carbohydrate, dietary intervention used in conjunction with exercise.

SUPPLEMENTAL TABLE 1 CONTINUED. Studies utilized for analysis of differences in effectiveness for eliciting alternations in measures of interest based on the duration of training and the modality of exercise.

Study	Exercise & Duration of Intervention	Summary Description of Exercise	Measures of Interest for comparison
Donnelly* [77]	ET: 5x's/wk for 16-wk	ET: 20-45 min @ 60%-75% HRR for ≈2000 kcal/wk (400 kcal/session)	Morph, VO_2
Honkola [78]	RT: 3x's/wk for 20-wk	RT: 2-set x 12-15 rep CRT for 8-10 whole body exercise (unknown exercises) @unknown intensity w/ <60-sec rest	Morph, SBP, DBP
Ibanez [79]	RT: 2-3x's/wk for 16-wk	RT‡: 3-4x10-15 @ 50-80% 1RM (progressive) CRT for 8-wks & 3-5x10-12@60-80% or 3-5x 4-6@80-90% alternate for 8-wks	Morph, Ob, Adip, Met S
Irving [80]	ET: 3-5x's/wk for 16-wk	ET: unknown time @ RPE of 10-12 equate to 300-400 kcal/session OR unknown time @ RPE of 15-17 to equate to 300-400 kcal/session	Morph, Ob, Adip, SBP, DBP, VO_2
Josse [81]	E+R: 7x's/wk	ET: 7x's/wk @ total expenditure of 250 kcal unknown duration or intensity	Morph, Il-6, TNF-α
	ET @ 7x's	RT: 3x10 unknown intensity & rest interval	
	RT @ 2x's for 16-wk		
Layman [82]	E+R: 5x's/wk	ET‡: 30-min @ unknown intensity	Morph, Ob, Adip
	ET @ 5x's	RT‡: 1x12 @ unknown resistance intensity for 7 exercise in CRT	
	RT @ 2x's for 16-wk		
Marks [83]	E+R or RT: 3x's/wk for 20-wk	ET‡: 12-36 min (progressive) @ 70-85% HRM	Morph
		RT‡: 2x8-12 @ 70-90% 1RM for: Leg Ext/Curl, Seated Row, Chest Press, Arm Ext/Curl, and abdominal curls, with unknown rest	
		ET&RT: 12-24 min of ET and 1 set of RT	
Rice [84]	ET: 5x's/wk	ET‡: 20-60 min @ 50-85% MHR (progressive)	Morph, T2DM
	RT: 3x's/wk for 16-wk	RT‡: 1x8-12 @ 8-12RM (progressive) for Leg Ext/Curl, Latissimus pull-over, Bench Press, Should Press, Arm Ext/Curl	
Snel [85]	ET: 5x's/wk for 16-wk	ET‡: @70% VO_{2max} with 4 sessions @ 30-min/session cyclergometer & 1 session @ 60-min/session (aerobic exercise session)	Morph, CRP, SBP, DBP, VO_2
Tjønna+ [86]	ET: 3x's/wk for 16-wk	Interval ET: 10-min @ 70% MHR followed by 4-cyles of 4-min: 3-min @ 90% MHR and 70% MHR, then 5-min @ 50-60% MHR	Morph, Adip, SBP, DBP, VO_2
		ET: 47-min @ 70% MHR	
Tokmakidis* [44]	E+R: 4x's/wk	ET: 40-45 min/session treadmill @ 60-80% HR_{max} (progressive)	Morph, T2DM
	(2 ET, 2 RT) for 16-wk	RT: 3 set x 12 rep @ 60% 1RM for bench press, seated row, leg extension, lateral pull-down, pec-deck, leg curl and 45-60 sec rest per set and 180-240 sec rest per exercise	
Toledo [87]	ET: 6x's/wk for 20-wk	ET‡: 30-40 min/session (progressive) @ 60-70% HR_{max}	Morph, VO_2
Wycherley [88]	RT: 3x's/wk for 16-wk	RT‡: 2x8-12@70-85% 1RM for Leg Press, Leg Ext, Chest Press, Latissimus Pull-down, Seated Row, Arm Ext w 60 s rest	Morph, CRP, SBP, DBP, VO_2
		24-36 weeks	
Borg* [89]	ET: 3x's/wk for 24-wk	ET‡: 45 min @ 60-70% VO_{2max}	Morph, T2DM
		RT‡: 3x8 @ 60-80% 1RM CRT	
Brochu [90]	RT: 3x's/wk for 24-wk	RT‡: 3-4 x 8-12 @ 65-80% 1RM (progressive) for (Leg Press, Chest Press, Lateral Pulldown, Shoulder Press, Arm Curl/Ext) w/ 60-90 s rest	Morph, CRP, SBP, DBP
Carr* [91]	ET: 3x's/wk for 24-wk	ET‡: 60-min/session @ 70% HRR	Morph, VO_2

Note: Morph indicates any measure of body morphology/composition (e.g., body mass, fat mass or fat-free mass) and T2DM (e.g., fasting levels of glucose, insulin or HbA1c); and D indicates a dietary component to the intervention. All other abbreviations are noted within the list of abbreviations and generally agreed upon abbreviations for hormones. * Indicates study has data for analysis at multiple time points. +Indicates some results mirror previous reports from author and only utilized once within a time period for analysis. ‡Indicates a hypocaloric, or diabetic/low carbohydrate, dietary intervention used in conjunction with exercise.

SUPPLEMENTAL TABLE 1 CONTINUED. Studies utilized for analysis of differences in effectiveness for eliciting alternations in measures of interest based on the duration of training and the modality of exercise.

Study	Exercise & Duration of Intervention	Summary Description of Exercise	Measures of Interest for comparison
Church [92]	ET, RT, or E+R: 3x's/wk for 36-wk	ET: 50-min/session @ 50-80% VO_{2max} equated to 12 kcal/kg body mass per wk	Morph, T2DM
		RT: 2 set x 10-12 rep for bench press, seated row, shoulder press, lateral pull-down; 3 set x 10-12 rep for leg press, leg extension, leg flexion @ 12 RM	
		E+R: Same as ET (limited to 10 kcal/kg per wk) and RT (limited to 1 set for all exercises)	
Dobrosielski [93]	E+R: 3x's/wk for 26-wk	ET: 45-min/session @ 60-90% HR_{max}	Morph, SBP, DBP, VO_2
		RT: 2-sets x 10-15 reps for 7 exercises (unknown whole body) @ 50% 1RM	
Dobrosielski+ [94]	E+R: 3x's/wk for 26-wk	ET: unspecified	Morph, VO_2
		RT: unspecified	
		Both in accordance with American College Sports Medicine (ACSM) guidelines	
Donnelly* [77]	ET: 5x's/wk for 36-wk	ET: 20-45 min @ 60%-75% HRR for 1st 24-wks then 55%-70% of HRM (progressive) for ≈2000 kcal/wk (400 kcal/session)	Morph, VO_2
Dunstan [95]	RT: 3-4x's/ wk for 24-wk	RT‡: 3x8-10 @ 50-85% 1RM (progressive) for Bench Press, Leg Ext/Curl, Upright Row, Lateral Pull-down, Shoulder Press, Arm Curl/Ext, Abdominal exercises	Morph
Hansen* [35]	ET: 3x's/wk for 24-wk	Equivalent energetics (1.3±0.05 MJ/session)	Morph, VO_2
		ET: Low: 55-min/session @ 50%VO_{2peak} on ergometer; High: 40-min/session @ 75% VO_{2peak} on ergometer	
Karstoft [96]	ET: 5x's/wk for 24-wk	ET @ equated energetic demand for 60-min/session @ 55% VO_{2peak}, or Interval @ 3-min intervals for 60-min/session @ 1:1 ratio of high (>70% VO_{2peak}) and low (self-paced <70% VO_{2peak})	Morph, SBP, DBP, VO_2
Ryan [97]	RT or E+R: 3x's/wk for 24-wk	ET‡: 45-min @ 50-75% HRR (progressive)	Morph
		RT‡: variable resistance for 15-rep (3RM to 15 RM) 2-3 sets for Leg Press, Chest Press, Chest Flies, Latissimus Pull-down, Leg Curl/Ext, Arm Curl/Ext w/ 30 s rest	
Sigal* [71]	ET, RT, or E+R: 3x's/wk for 24-wk	ET‡: 15-min/session @60% HR_{max} & 45-min/session @ 75% HR_{max}	Morph, T2DM
		RT‡: 2-3 sets x 7-9 reps for 7-whole body exercises @ unknown intensity or rest interval	
		E+R‡: full version of both ET and RT	
Volpe [98]	ET: 3x's/wk for 36-wk	ET‡: 15-30 min for 3-5 x's/wk (progressive) @ unknown intensity via ski-ergometer	Morph, Ob, SBP, DBP, VO_2
Watkins [99]	ET: 3-4x's/ wk for 26-wk	ET‡: 30-35 min @ 70-80% HRR	Morph, SBP, DBP, VO_2
		>36 weeks	
Albu [100]	ET: Unknown for 52-wk	ET‡: general PA @ >175 min/wk of unknown intensity	Morph, T2DM
Anderssen [101]	ET: 3x's/wk for 52-wk	ET‡: 60–80% of PHR for 60-min	Morph, Ob, Adip, VO_2
Balducci+ [102]	ET or E+R: 2x's/wk for 52-wk	Equal energetics for ET & E+R progressive	Morph, Ob, Adip, Il-6, TNF-α, CRP, SBP, DBP, VO_2, T2DM
		ET: unknown duration or intensity OR 60-min @ 70-80% VO_{2max}	
		E+R: 40-min ET @ 70-80% VO_{2max}, RT of 4 exercises (chest press, lateral pull-down, squat, abdominal exercise) @ 80% 1 RM with unknown set x rep and rest interval	

Note: Morph indicates any measure of body morphology/composition (e.g., body mass, fat mass or fat-free mass) and T2DM (e.g., fasting levels of glucose, insulin or HbA1c); and D indicates a dietary component to the intervention. All other abbreviations are noted within the list of abbreviations and generally agreed upon abbreviations for hormones. * Indicates study has data for analysis at multiple time points. +Indicates some results mirror previous reports from author and only utilized once within a time period for analysis. ‡Indicates a hypocaloric, or diabetic/low carbohydrate, dietary intervention used in conjunction with exercise.

SUPPLEMENTAL TABLE 1 CONTINUED. Studies utilized for analysis of differences in effectiveness for eliciting alternations in measures of interest based on the duration of training and the modality of exercise.

Study	Exercise & Duration of Intervention	Summary Description of Exercise	Measures of Interest for comparison
Balducci+ [103]	E+R: 2x's/ wk for 52-wk	E+R progressive ET‡: unknown duration, unknown intensity RT‡: 4 exercises (chest press, lateral pull-down, squat, abdominal exercises) @ unknown intensity, rep or set count and rest intervals	Morph, CRP, SBP, DBP, VO_2, T2DM
Balducci+ [104]	E+R: 2-3x's/ wk for 52-wk	E+R progressive ET: 55-70% VO_{2max} on ergometer (stair, treadmill, cycle) for unknown duration/session RT: 3 sets x 10 reps of 4 exercises (chest press, lateral pull-down, squat, abdominal exercises) @ 60-80% 1RM with unknown rest	Morph, CRP, SBP, DBP, VO_2, T2DM
Balducci+ [105]	E+R: 2-3x's/ wk for 52-wk	E+R progressive ET: unknown duration RT: 4 exercises (chest press, lateral pull-down, squat, abdominal exercises) @ unknown volume and rest interval E+R: Low @ 55% VO_{2max} & 60% 1RM High @ 70% VO_{2max} & 60% 1RM	Morph, CRP, SBP, DBP, VO_2, T2DM
Borg* [89]	ET: 3x's/wk for 40-wk	ET‡: 45 min @ 60-70% VO_{2max} RT‡: 3x8 @ 60-80% 1RM CRT	Morph, T2DM
Carr* [91]	ET: 3x's/wk for 104-wk	ET‡: 60-min/session @ 70% HRR	Morph, VO_2, T2DM
Donnelly* [77]	ET: 5x's/wk for 52-wk and 68-wk	ET: 20-45 min @ 60%-75% HRR for 1st 24-wks then 55%-70% of HRM (progressive) for ≈2000 kcal/wk (400 kcal/session)	Morph, VO_2
Hawkins [106]	ET: 6x's/wk for 52-wk	ET: 60 min/session @ 60-85% HR_{max} either on ergometer or via community walking	Morph, VO_2
Heufelder [107]	E+R: 3x's/wk for 52-wk	ET‡: 30 min/session @ unspecified intensity RT‡: unspecified	Adip, CRP, SBP, DBP
Olson [108]	RT: 2x's/wk for 52-wk	RT: 3x8–10 @ 8-10RM (Progressive) for unknown exercises indicated as isotonic variable resistance machines and free weights targeting the following major muscle groups: quadriceps, hamstrings, gluteals, pectorals, latissimus dorsi, rhomboids, deltoids, biceps and triceps	Morph, Adip, Il-6, CRP, SBP, DBP, T2DM
Pritchard [109]	ET: 5x's/wk for 52-wk	ET: 30-45 min @ 65-75% HRM	Morph, T2DM
Rokling-Andersen [110]	ET: 3x's/wk for 52-wk	ET‡: 60-min/session of self-selected "aerobic" exercise or running @ unknown intensity	Morph, Adip, CRP, TNF-α, Il-6
Yavari [111]	ET, RT, or E+R: 3x's/wk for 52-wk	ET: 20-60 min/session (progressive) @ 60-70% HR_{max} (progressive) on treadmill or cyclergometer RT: 3 set x 8-10 rep for bench press, seated row, shoulder press, lateral pull-down, abdominal crunch, leg press, leg extension, triceps pushdown, seated bicep curl @ 60-80% 1RM (progressive) with 90-120 sec rest intervals E+R: ET @ 20-30 min/session @ 60-70% HR_{max} (progressive) on treadmill or cyclergometer & RT @ 2 set x 8-10 rep for bench press, seated row, shoulder press, lateral pull-down, abdominal crunch, leg press, leg extension, triceps pushdown, seated bicep curl @ 60-80% 1RM (progressive) with 90-120 sec rest intervals	Morph, SBP, DBP, VO_2, T2DM

Note: Morph indicates any measure of body morphology/composition (e.g., body mass, fat mass or fat-free mass) and T2DM (e.g., fasting levels of glucose, insulin or HbA1c); and D indicates a dietary component to the intervention. All other abbreviations are noted within the list of abbreviations and generally agreed upon abbreviations for hormones. * Indicates study has data for analysis at multiple time points. +Indicates some results mirror previous reports from author and only utilized once within a time period for analysis. ‡Indicates a hypocaloric, or diabetic/low carbohydrate, dietary intervention used in conjunction with exercise.