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Original Research Article

Personalized, Adaptive Resistance Training is Superior to Traditional Resistance Exercise – A Randomized, Controlled Trial

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ABSTRACT

Purpose: The purpose of this study was to compare muscular fitness, anthropometric, and cardiorespiratory fitness outcomes between personalized, adaptive resistance training (ARX) and traditional moderate-intensity resistance exercise (MI-RE). **Methods:** Apparently healthy men and women (N=45) who reported no resistance training within the previous six months were randomized to a non-exercise control group or one of two resistance exercise training treatment groups (MI-RE or ARX). Measurements of all primary (muscular fitness) and secondary (anthropometric and cardiorespiratory) outcomes were obtained both before and after the 12wk resistance training intervention. Additionally, measures of the primary outcome variable (muscular fitness) were also obtained at the 6wk midpoint. Muscular fitness was assessed by one-repetition maximum (1RM) and five-repetition maximum (5RM) testing for 10 different resistance training exercises. **Results:** Percentage body fat and cardiorespiratory fitness (VO_2max) improved significantly ($p < 0.05$) following 12wk resistance training in both groups; however, these improvements were more pronounced ($p < 0.05$) in the ARX group. Furthermore, similar findings were also observed for changes in weight and waist circumference across the 12wk intervention with both MI-RE and ARX groups showing favorable reductions, with the ARX group exhibiting superior changes. At 6wk (i.e., midpoint) and 12wk, all 1RM and 5RM measures for all resistance exercises, were significantly greater ($p < 0.05$) relative to the control group. In the ARX treatment group, the baseline to 12wk Δ in all 1RM and 5RM measures were significantly greater ($p < 0.05$) to those in the control and MI-RE treatment group, with the exception ($p > 0.05$) of the MI-RE baseline to 12wk Δ in leg press 5RM, tricep extension 1RM and 5RM, and bicep curl 5RM. **Conclusion:** The tremendous potential for different modalities of evidence-based exercise programming to enhance training efficacy warrants ongoing scientific inquiry. Given that 'lack of time' is the most often cited reason for not exercising regularly, this study aimed to provide preliminary evidence that extended application of the reduced exertion high intensity training (REHIT) paradigm from aerobic to resistance exercise using technology in the form of the ARX, which permitted personalized, effective, and safe programming. Collectively, these findings have the potential to provide exercise professionals with another important training paradigm to assist individuals with achieving their health and fitness goals.

KEYWORDS: Cardiorespiratory Fitness, Energy Expenditure, Exercise Intensity, Muscular Fitness.

Introduction

Regular physical activity confers various health benefits including the prevention and management of hypertension, obesity, Type 2 diabetes, dyslipidemia, and cardiovascular disease[1]. However, despite the long-existence of exercise-related health promotions, engagement in physical activities or exercise remains scarce, primarily reported to be due to 'lack of time'[2]. High-intensity interval training (HIIT) therefore has captivated attention of many researchers due to its superior ability to improve cardiorespiratory fitness[3] and vascular function[4] for a lesser weekly time-commitment relative to the current exercise guideline of moderate-intensity continuous training (MICT). High intensity interval training (HIIT) involves alternating brief bouts (30 sec–5 min) of higher intensity sessions with either rest or lower-intensity workloads throughout an exercise routine. HIIT has traditionally encompassed aerobic modalities. Regular resistance exercise is also recommended in the most recent exercise prescription guidelines[1]. Adaptive Resistance Exercise (ARX) is a recently developed personalized resistance exercise product that incorporates a modified form of HIIT called reduced exertion high intensity training (REHIT). Specifically, ARX is resistance training technology that uses computer-controlled, motorized resistance in place of weights or other more traditional forms of resistance. This "adaptive resistance" provides safe, controlled, and quantifiable resistance that is of a higher quality than is currently possible with weights or other gravity-based systems found in the world today. However, it remains unknown if the ARX REHIT paradigm can be successfully applied in a real world setting and yield superior benefits relative to traditional moderate-intensity resistance exercise (MI-RE) in a time-efficient fashion. This gap in the literature prompted the present study. The purpose of this study was to compare muscular fitness, anthropometric, and cardiorespiratory fitness outcomes between personalized ARX and traditional MI-RE. It was hypothesized that personalized ARX would elicit superior outcomes when compared to traditional MI-RE.

Methods

Participants

A cohort of (N=45) nonsmoking men and women (18 to 65 yrs) were recruited from the student and faculty population of a local university, as well as the surrounding community, via advertisement through the university website, local community newspaper, and word-of-mouth. Participants were eligible for inclusion into the study if they reported no resistance training within the previous six months. Participants were also eligible for inclusion into the study if they verbally agreed to continue previous dietary habits and not perform additional exercise beyond that required for the present study. Exclusionary criteria included evidence of cardiovascular pulmonary, and/or metabolic disease. This study was approved by the Human Research Committee at Western Colorado University.

Each participant signed an informed consent form prior to participation.

Experimental design

Randomization and resistance exercise intervention

After the completion of baseline testing, participants were randomized to a non-exercise control group (n=15) or one of two resistance exercise training treatment groups (N=30 split across the two treatment groups). Participants randomized to the resistance exercise training groups performed 12wk of exercise training according to one of two resistance exercise intensity regimens: 1) personalized ARX or 2) traditional MI-RE whereby intensity was prescribed according to ACSM guidelines[1]. The MI-RE treatment group performed the following exercises: bench press, shoulder press, lateral pulldown, seated row, bicep curl, tricep pushdown, seated leg press, seated leg extension, prone lying leg curl, and seated back extension/flexion. The ARX treatment group performed the following exercises on the Alpha ARX unit according to manufacturer guidelines: leg press, seated row, torso extension, chest press, calf raise, and torso flexion. The MI-RE group also performed a 3min light aerobic warmup and 2min range of motion exercises. All other exercise prescription details for each resistance training group over the course of the 12wk training period are presented in Table 1.

Baseline, midpoint, and post-program testing procedures

Measurements of all primary and secondary outcome variables were obtained both before and after the 12wk resistance training intervention. Additionally, measures of the primary outcome variable (muscular fitness) were also obtained at the 6wk midpoint. Secondary outcome variables consisted of basic anthropometric measures (height/weight/waist circumference/body composition), and cardiorespiratory fitness via maximal oxygen uptake (VO_2max). All measurements were obtained by following standardized procedures as outlined elsewhere[1]. Procedures for each measurement are also briefly described below. Prior to testing participants were instructed to avoid caffeine and food or beverages with caloric value for 12 hours prior to testing. Participants were permitted to consume water *ad libitum*. Participants were also instructed to refrain from strenuous exertion 12 hours prior to testing. All post-program testing took place within 1 to 4 days of the last resistance training session.

Table 1. Exercise prescription for MI-RE and ARX groups.

MI-RE Group

Weeks	Days/wk	Sets/Reps	Intensity
1-2	2	1/10	60% 1RM
3-4	2	1/12	70% 1RM
5-7	2	2/12	70% 1RM
8-12	3	2/12	70% 1RM

ARX Group

Weeks 1-2

- Performed as a Super Set Complex (i.e., no more than 20 sec between all sets)

Days	Exercise	Sets	Reps	Tempo (C/E)
M/Th	Torso Extension	1	6	7 sec / 7 sec
M/Th	Leg Press	1	6	7 sec / 7 sec
M/Th	Chest Press	1	6	7 sec / 7 sec
M/Th	Row	1	6	7 sec / 7 sec
M/Th	Torso Flexion	1	0	Static :60
M/Th	Calf Raise	1	0	Static :60

Weeks 3-4

- Performed as a Super Set Complex (i.e., no more than 20 sec between sets)

Days	Exercise	Sets	Reps	Tempo (C/E)	Rest Between Reps
M/Th	Torso Extension	1	6	7 sec / 7 sec	3 sec
M/Th	Leg Press	1	6	7 sec / 7 sec	3 sec
M/Th	Chest Press	1	6	7 sec / 7 sec	3 sec
M/Th	Row	1	6	7 sec / 7 sec	3 sec
M/Th	Torso Flexion	1	0	Static :75	N/A
M/Th	Calf Raise	1	0	Static :75	N/A

Weeks 5-12

- Performed as 2 Super Sets (i.e., 20 sec between sets)
- Torso Extension & Leg Press = Super Set 1; Chest Press & Row = Super Set 2
- Performed last two static exercises as independent sets (i.e., 20 sec between sets)

Days	Exercise	Sets	Reps	Tempo (C/E)	Rest Between Reps
M/Th	Torso Extension	1	4	7 sec / 7 sec	3 sec
M/Th	Leg Press	1	4	7 sec / 7 sec	3 sec
M/Th	Torso Extension	1	4	7 sec / 7 sec	3 sec
M/Th	Leg Press	1	4	7 sec / 7 sec	3 sec
M/Th	Chest Press	1	4	7 sec / 7 sec	3 sec
M/Th	Row	1	4	7 sec / 7 sec	3 sec
M/Th	Chest Press	1	4	7 sec / 7 sec	3 sec
M/Th	Row	1	4	7 sec / 7 sec	3 sec
M/Th	Torso Flexion	1	0	Static :90	N/A
M/Th	Calf Raise	1	0	Static :90	N/A

Maximal resistance exercise testing to assess muscular fitness

The procedures for assessment of muscular fitness assessment outlined elsewhere were followed[5]. Participants performed one-repetition maximum (1RM) and five-repetition maximum (5RM) testing for the following resistance exercises: back extension, bicep curl, chest press, lateral pulldown, leg curl, leg extension, leg press, seated row, shoulder press, and tricep extension. The following protocol was used for 1RM and 5RM testing:

1. 10 repetitions of a weight the participant felt comfortable lifting (40-60% of estimated 1RM) were performed to warm up muscles followed by 1 minute rest period
2. 5 repetitions at weight of 60-80% estimated 5RM was performed as a further warm up and followed by a 2 minute rest period
3. First 5RM attempt at weight of 2.5-20kg greater than warm up
    - If first 5RM lift was deemed successful by the researcher (appropriate lifting form) weight was increased until maximum weight participant can lift was established with 3 minutes between each attempt.
    - If first 5RM lift deemed unsuccessful by the researcher, weight was decreased until participant successfully lifted the heaviest weight possible
4. First 1RM attempt at weight of 2.5-20kg greater than 5RM
    - If first 1RM lift was deemed successful by the researcher (appropriate lifting form) weight was increased until maximum weight participant can lift was established with 3 minutes between each attempt.
    - If first 1RM lift deemed unsuccessful by the researcher, weight was decreased until participant successfully lifted the heaviest weight possible.

There were 2-3 minutes rest between 1RM and 5RM attempts and a maximum of 3 x 1RM and 5RM attempts. There were 3 minutes of rest between the 1RM and 5RM testing of each resistance exercise.

Maximal exercise testing procedures

Participants completed a maximal graded exercise test (GXT) on a motorized treadmill (Powerjog GX200, Maine, USA). Participants walked or jogged at a self-selected pace. Treadmill incline was increased by 1% every minute until the participant reached volitional fatigue. Participant HR was continuously recorded during the GXT via a chest strap and radio-telemetric receiver (Polar Electro, Woodbury, NY, USA). Expired air and gas exchange data were recorded continuously during the GXT using a metabolic analyzer (Parvo Medics TrueOne 2.0, Salt Lake City, UT, USA). Before each exercise test, the metabolic analyzer was calibrated with gases of known concentrations (14.01 ± 0.07% O_2, 6.00 ± 0.03% CO_2) and with room air (20.93%O_2 and 0.03% CO_2) as per the instruction manual.

Volume calibration of the pneumotachometer was done via a 3-Litre calibration syringe system (Hans-Rudolph, Kansas City, MO, USA). Gas exchange data were averaged for every 15 sec and VO_2max was determined by averaging the final two valid 15 sec VO_2 samples. The highest achieved HR during the GXT was considered the maximal HR (HR_{max}).

Statistical Analyses

All analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (Armonk, NY: IBM Corp) and GraphPad Prism 8.0. (San Diego, CA). Measures of centrality and spread are presented as mean ± standard deviation (SD). All baseline-dependent variables were compared using general linear model (GLM) ANOVA and, where appropriate, Tukey post hoc tests. Within-group comparisons were made using paired t-tests and one-way repeated measures ANOVA. Additionally, the effect of resistance exercise training on muscular fitness (i.e., all 1RM and 5RM values) were determined by comparing the baseline to 12wk changes (Δ's) across groups (control, MI-RE, and ARX) using GLM-ANOVA. The assumption of normality was tested by examining normal plots of the residuals in ANOVA models. Residuals were regarded as normally distributed if Shapiro-Wilk tests were not significant[6]. The probability of making a Type I error was set at $p \leq 0.05$ for all statistical analyses.

Results

All analyses and data presented in the results are for those participants who completed the investigation. At baseline, treatment (MI-RE and ARX) and non-exercise control groups did not differ significantly in physical or physiological characteristics. The physical and physiological characteristics for participants are shown in Table 2. The resistance exercise training in both treatment groups was well tolerated for the 27 of 30 participants who completed the study. Three participants were unable to complete the study for the following reasons: out-of-town move (n = 1) and unknown reasons (n = 2). Dropout was similar in both treatment groups. Percentage body fat and VO_2max improved significantly ($p < 0.05$) following 12wk resistance training in both treatment groups; however, these improvements were more pronounced ($p < 0.05$) in the ARX group. Furthermore, similar findings were also observed for changes in weight and waist circumference across the 12wk intervention with both MI-RE and ARX groups showing favorable reductions, with the ARX group exhibiting superior changes ($p < 0.05$).

Table 2. Physical and physiological characteristics at baseline and 12wk for control, MI-RE, and ARX groups (mean ± SD).

Parameter	Control group (n=14)		MI-RE group (n=14)		ARX group (n=13)	
	Baseline	12wk	Baseline	12wk	Baseline	12wk
Age (yr)	39.5 ± 12.5	____	38.9 ± 11.1	____	40.3 ± 15.5	____
Height (cm)	169.4 ± 6.7	____	170.4 ± 9.1	____	168.0 ± 8.4	____
Weight (kg)	70.3 ± 12.4	71.2 ± 11.9*	72.4 ± 14.0	71.9 ± 13.8*†	69.8 ± 10.7	68.1 ± 10.0*‡
Waist circumference (cm)	80.2 ± 6.8	80.8 ± 6.0	82.9 ± 9.3	82.4 ± 8.9	81.8 ± 6.7	79.7 ± 6.1*‡
Body fat (%)	25.2 ± 5.7	26.1 ± 6.1*	27.7 ± 5.5	26.0 ± 4.9*†	27.3 ± 6.5	22.9 ± 5.9*‡
VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	33.0 ± 6.2	32.5 ± 6.0	32.1 ± 7.7	33.6 ± 9.4†	34.1 ± 6.3	39.3 ± 6.0*‡

* Within-group change is significantly different from baseline, $p < 0.05$; † Change from baseline is significantly different than control group, $p < 0.05$; Change from baseline is significantly different than control and MI-RE groups, $p < 0.05$.

Muscular fitness outcomes

At 6wk (i.e., midpoint) and 12wk, all 1RM and 5RM measures for all resistance exercises, were significantly greater ($p < 0.05$) relative to the control group (Tables 3 and 4). In the ARX treatment group, the baseline to 12wk Δ in all 1RM and 5RM measures were significantly greater ($p < 0.05$) to those in the control and MI-RE treatment group, with the exception ($p > 0.05$) of the MI-RE baseline to 12wk Δ in leg press 5RM, tricep extension 1RM and 5RM, and bicep curl 5RM (Figures 1 and 2).

Table 3. Resistance exercise 1RM values at baseline, midpoint, and 12wk for control, MI-RE, and ARX groups (values are mean ± SD).

	Control group (n=14)			MI-RE group (n=14)			ARX group (n=13)		
Resistance exercise	**Baseline**	**midpoint**	**12wk**	**Baseline**	**midpoint**	**12wk**	**Baseline**	**midpoint**	**12wk**
Back extension (lbs)	205.0 ± 77.5	20.3.6 ± 83.0	206.8 ± 82.9	231.8 ± 57.9	242.1 ± 52.5	251.1 ± 49.3†‡	229.6 ± 51.8	252.3 ± 48.1*	273.9 ± 47.1†‡
Bicep curl (lbs)	102.9 ± 41.4	100.4 ± 39.1	102.1 ± 41.4	84.3 ± 39.6	93.6 ± 41.2*	99.6 ± 42.2†‡	95.0 ± 45.1	104.2 ± 44.5*	120.4 ± 43.4†‡
Chest press (lbs)	148.9 ± 48.8	150.0 ± 49.6	150.7 ± 47.4	113.9 ± 53.2	122.9 ± 55.8	131.8 ± 54.8†‡	136.9 ± 67.3	154.6 ± 68.7*	177.7 ± 71.1†‡
Lateral pulldown (lbs)	139.6 ± 37.1	139.3 ± 39.0	137.1 ± 40.1	113.2 ± 45.1	124.6 ± 41.9*	128.9 ± 43.3†‡	124.6 ± 39.8	139.6 ± 42.8*	153.9 ± 41.3†‡
Leg curl (lbs)	147.9 ± 47.5	153.6 ± 47.2*	149.3 ± 48.0	136.8 ± 48.7	150.0 ± 46.3*	159.3 ± 42.8†‡	160.0 ± 52.6	175.8 ± 52.0*	200.0 ± 50.7†‡
Leg extension (lbs)	204.3 ± 60.4	201.4 ± 59.8	204.6 ± 61.4	176.4 ± 60.6	190.4 ± 66.2	208.2 ± 60.2‡	198.9 ± 48.3	214.2 ± 53.6*	243.9 ± 54.9†‡
Leg press (lbs)	443.6 ± 171.7	439.3 ± 172.1	437.9 ± 169.5	328.2 ± 128.6	374.0 ± 123.1*	410.0 ± 143.3†‡	361.9 ± 164.4	437.1 ± 180.9*	494.9 ± 207.2†‡
Seated row (lbs)	130.7 ± 47.0	131.1 ± 47.7	131.8 ± 46.6	115.7 ± 52.1	129.6 ± 52.0*	136.4 ± 54.3†‡	122.3 ± 43.9	138.1 ± 42.9*	156.9 ± 41.0†‡
Shoulder press (lbs)	95.4 ± 39.4	92.5 ± 37.5	98.9 ± 34.8†	66.4 ± 47.1	73.2 ± 45.4*	79.3 ± 47.2†‡	78.5 ± 50.8	93.9 ± 52.3*	115.0 ± 51.8†‡
Tricep extension (lbs)	102.1 ± 30.9	101.1 ± 27.5	104.6 ± 33.1	83.2 ± 35.9	95.0 ± 36.9*	100.7 ± 39.2†‡	90.8 ± 33.7	100.8 ± 35.5*	110.8 ± 40.0†‡

* Midpoint is significantly different from baseline, $p < 0.05$; † 12wk is significantly different from midpoint, $p < 0.05$; ‡ 12wk is significantly different from baseline, $p < 0.05$.

Table 4. Resistance exercise 5RM values at baseline, midpoint, and 12wk for control, MI-RE, and ARX groups (values are mean ± SD).

	Control group (n=14)			MI-RE group (n=14)			ARX group (n=13)		
Resistance exercise	**Baseline**	**midpoint**	**12wk**	**Baseline**	**midpoint**	**12wk**	**Baseline**	**midpoint**	**12wk**
Back extension (lbs)	182.9 ± 56.3	184.6 ± 56.8	181.1 ± 51.5	205.0 ± 59.9	218.2 ± 55.9*	228.2 ± 52.9†‡	194.2 ± 45.9	215.0 ± 41.5*	245.0 ± 43.8†‡
Bicep curl (lbs)	86.4 ± 33.7	89.6 ± 33.4	87.9 ± 36.5	71.8 ± 37.1	81.1 ± 38.4*	87.9 ± 38.9†‡	79.6 ± 35.5	89.6 ± 35.5*	100.4 ± 36.6†‡
Chest press (lbs)	105.4 ± 32.1	106.1 ± 32.8	104.6 ± 32.6	91.8 ± 44.3	98.6 ± 45.1*	107.9 ± 44.6†‡	101.5 ± 42.9	118.1 ± 47.9*	135.8 ± 49.4†‡
Lateral pulldown (lbs)	122.1 ± 40.2	122.9 ± 39.5	125.7 ± 39.2	96.8 ± 42.4	109.3 ± 42.7*	117.5 ± 43.3†‡	106.5 ± 40.8	120.0 ± 39.8*	136.9 ± 43.4†‡
Leg curl (lbs)	125.4 ± 43.6	127.1 ± 42.8	123.2 ± 43.0	111.8 ± 43.9	126.4 ± 43.9*	137.9 ± 43.2†‡	129.6 ± 44.1	148.5 ± 44.6*	168.5 ± 41.7†‡
Leg extension (lbs)	154.6 ± 44.4	153.2 ± 47.0	153.9 ± 46.4	140.4 ± 45.7	156.4 ± 46.4*	170.4 ± 46.4†‡	146.2 ± 39.6	165.0 ± 46.9*	191.5 ± 45.3†‡
Leg press (lbs)	329.6 ± 133.2	336.8 ± 129.7	334.6 ± 122.8	265.0 ± 105.3	316.9 ± 122.3*	348.6 ± 135.2†‡	283.1 ± 123.9	350.9 ± 140.6*	408.6 ± 166.0†‡
Seated row (lbs)	112.1 ± 44.9	114.3 ± 47.1	115.4 ± 46.6	96.1 ± 43.6	108.2 ± 44.4*	116.4 ± 46.3†‡	97.3 ± 36.6	113.9 ± 38.8*	127.3 ± 40.9†‡
Shoulder press (lbs)	75.0 ± 34.2	78.6 ± 35.5	76.8 ± 36.4	53.2 ± 42.8	60.4 ± 42.7*	65.4 ± 42.7†‡	62.7 ± 41.7	75.8 ± 44.6*	92.7 ± 43.5†‡
Tricep extension (lbs)	82.9 ± 28.8	84.3 ± 31.2	83.6 ± 29.5	67.2 ± 32.9	77.5 ± 32.2*	86.4 ± 33.4†‡	75.8 ± 32.8	87.7 ± 33.0*	97.3 ± 36.6†‡

* Midpoint is significantly different from baseline, $p < 0.05$; † 12wk is significantly different from midpoint, $p < 0.05$; ‡ 12wk is significantly different from baseline, $p < 0.05$.

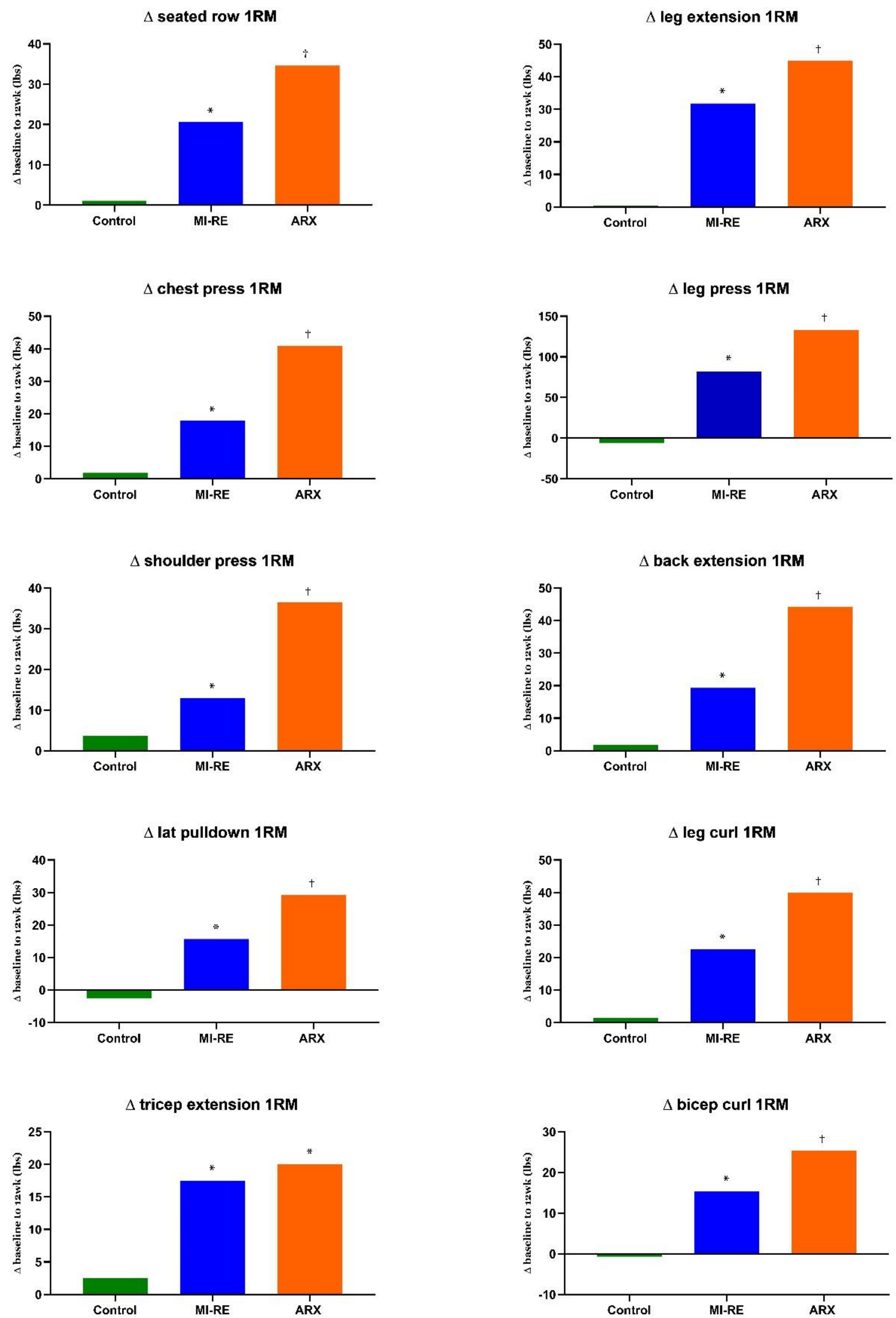

Figure 1. Baseline to 12wk Δ in 1RM values for all resistance exercises for control, MI-RE, and ARX groups (values are mean). * significantly greater ($p < 0.05$) baseline to 12wk Δ relative to control group; † significantly greater ($p < 0.05$) baseline to 12wk Δ relative to both MI-RE and control groups.

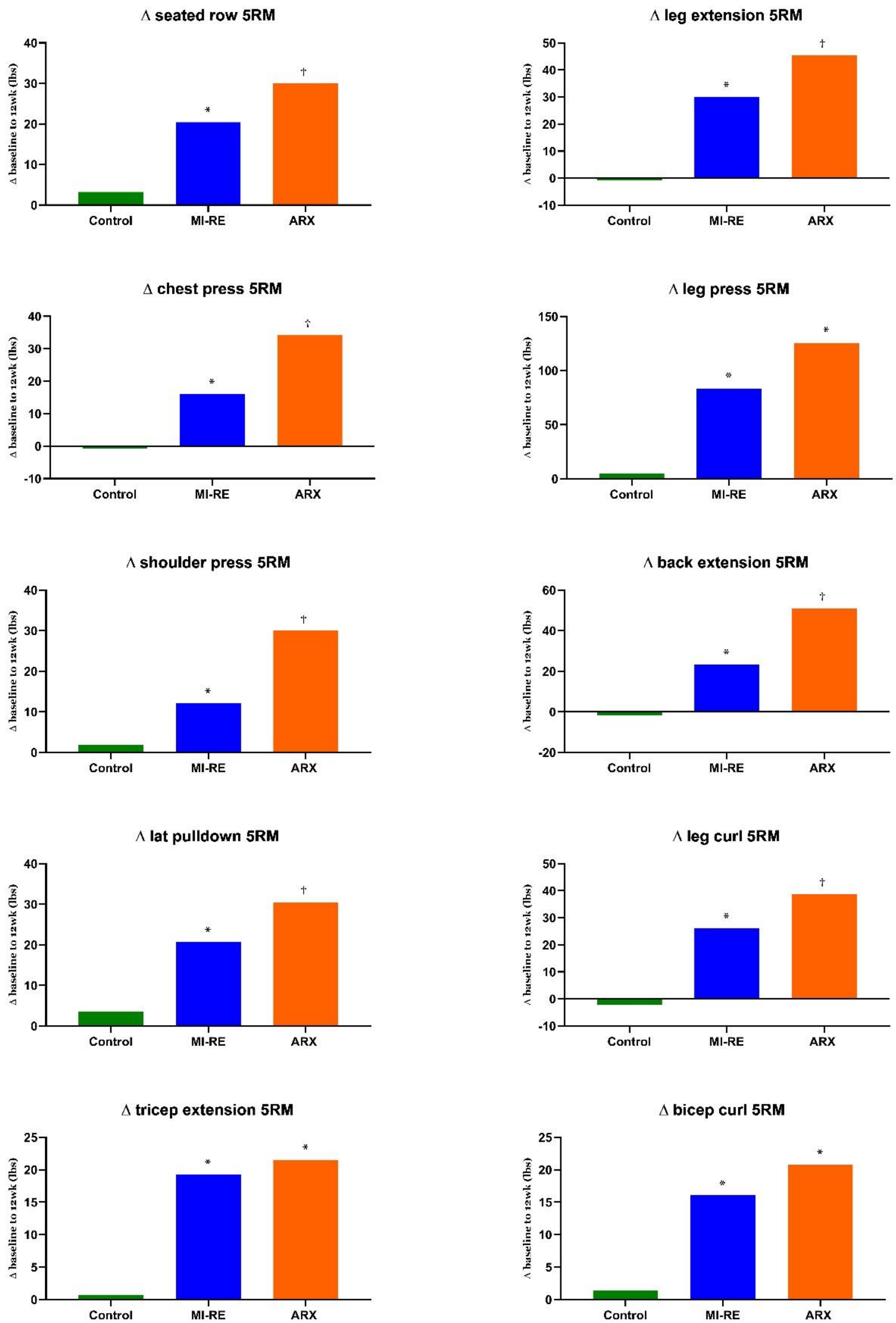

Figure 2. Baseline to 12wk Δ in 5RM values for all resistance exercises for control, MI-RE, and ARX groups (values are mean). * significantly greater ($p < 0.05$) baseline to 12wk Δ relative to control group; † significantly greater ($p < 0.05$) baseline to 12wk Δ relative to both MI-RE and control groups.

Discussion

There are three key take away findings from the present study:

1. ARX is superior to traditional MI-RE at improving muscular fitness.
2. Relative to MI-RE, ARX elicits larger reductions in % body fat and greater improvements in VO_2max.
3. ARX achieves favorable training adaptations in a time-efficient manner, as it required approximately 33% the time of MI-RE workouts. The average ARX sessions were 15min in duration. In contrast, the average MI-RE sessions were 45min in duration.

In the past decade, low muscular fitness has garnered considerable attention as an independent and powerful predictor of cardiovascular disease (CVD) risk and premature mortality. Indeed, it has been reported that increased muscular fitness is associated with a reduced risk of all-cause mortality[7]. Additionally, various muscular fitness parameters (strength, endurance and power) have been found to be associated with common cardiometabolic risk factors, including body mass index, waist circumference, blood lipids and blood pressure[8]. It also has been demonstrated that that there is a strong association between muscular strength and mortality from all causes in various clinical populations, including those with CVD, cancer and arthritis[9]. More recently, elevated levels of both upper- and lower-body muscular strength have been linked to lower risk of mortality[10]. Taken together, this body of scientific literature highlights the critical role of muscular fitness in public health. Overall, the results of this novel study are encouraging and support the tremendous potential to implement ARX into the training paradigm of adults who 'lack time' to prevent chronic disease and mortality.

Also, over the past decade, the concept of aerobic high-intensity interval training (HIIT) has captivated the attention of health and exercise professionals and researchers alike due to its superior ability to improve cardiorespiratory fitness[4] and cardiometabolic health[3] for a lesser weekly time commitment relative to the current exercise guideline of moderate-intensity continuous training (MICT)[11]. Resistance exercise can also be effectively performed as HIIT by alternating brief bouts of higher-intensity sessions with either rest or lower-intensity workloads throughout the exercise training session. This strategy enables less-fit individuals to accumulate periods of exercise that would otherwise not be possible if executed continuously. However, one drawback to the protocols employed in the majority of previous resistance-training HIIT studies is that they were not actually time-efficient[12-13]. For resistance training HIIT to be a feasible option to improve public health, it must be time-efficient as lack of time has consistently been identified as one of the primary perceived barriers to preventing inactive individuals from becoming and remaining physically active.

Accordingly, our experimental design in the present study addressed this issue with a total weekly time commitment of 30 to 45 minutes for the ARX group, which equated to 33% of the time-commitment when compared to the traditional MI-RE training group.

Safety is a paramount issue when designing and implementing a resistance-exercise HIIT program. Overall, properly performed exercise is harmless for the majority of individuals. In fact, there is a greater risk associated with remaining physically inactive when compared to commencing with regular exercise training. The absolute risk of sudden death during vigorous-intensity physical activity has been estimated to be one per year for every 15,000 to 18,000 people[1]. In terms of the specific risk associated with aerobic HIIT, it was found that after 129,456 hours of MICT and 46,364 hours of HIIT in 4,846 high-risk participants, there was one fatal and two non-fatal cardiac arrests, respectively[14]. Similarly, another recent study reported that across 12 randomized controlled trials, which compared aerobic MICT with HIIT, only a single adverse cardiac event (orthostatic collapse) occurred in the combined HIIT groups [15]. Overall, the consensus to-date in the scientific literature is that the risk of a cardiovascular event with aerobic HIIT is extremely low. Results from the present study corroborate these previous findings as there were no observed or reported safety issues with any study participants in the ARX treatment group. The study participants were representative of the typical U.S. adult population: young to middle-aged (18 to 64 years), not engaged in regular resistance exercise, and burdened with various cardiometabolic risk factors (e.g., obesity, high cholesterol, hypertension).

There are a few limitations to the present study that warrant further discussion. First, while participants were instructed to maintain their regular dietary intake during the 12wk intervention, diet intake was not strictly controlled for in this study. Moreover, physical activity/sedentary behavior outside of the training program and prescribed medications were not monitored, and thus may have influenced the current findings.

Conclusion

Low muscular fitness has recently garnered considerable attention as an independent and powerful predictor of chronic disease risk and premature mortality. The tremendous potential for different modalities of evidence-based exercise programming to enhance training efficacy warrants ongoing scientific inquiry. Given that ‘lack of time’ is the most often cited reason for not exercising regularly, this study aimed to provide preliminary evidence that extended application of the REHIT paradigm from aerobic to resistance exercise using technology in the form of the ARX, which permitted personalized, effective, and safe programming. Indeed, the ARX group's workouts only occupied 33% of the workout time compared with the MI-RE group (15 min vs. 45 min), yet conferred muscular fitness improvements that were 1.5 to 2-fold greater. These time-efficient and robust muscular fitness adaptations are attributable to the ARX technology, which uses personalized, motorized resistance and computer software that ensures individuals perform the optimal workout every time, thus assisting her or him to get progressively fitter and stronger over time. Collectively, these findings have the potential to provide exercise professionals with another important training paradigm to assist individuals with achieving their health and fitness goals.

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