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FITNESS

Comparison of Strength Gains in Untrained College-Age Females Using Free Weights and FreeMotion Machines

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Abstract

Resistance training has become a preferred method for developing muscular strength among various populations. A variety of resistance training modes are available, but there are mixed outcomes regarding strength development among barbells, dumbbells, and weight machines. The purpose of this study was to investigate the differences in strength improvements between dumbbell and FreeMotion machine training. Twenty college-age females were randomly assigned into dumbbell or FreeMotion groups, but only 8 in the dumbbell group completed. Both groups followed a nearly identical progressive strength training program on each of their training modes for 8 weeks. Participants were tested on their one-repetition max (1-RM) on a barbell bench press and barbell back squat before and after the intervention program. A repeated measures ANOVA analysis compared 1-RM changes between groups, and effect sizes were calculated. Significant increases in strength improvements ($p < .001$) were observed for the dumbbell

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and FreeMotion groups, with moderate effect size for the 1-RM barbell bench press (d = 0.56) and a moderate to large effect size for the 1-RM barbell back squat (d = 0.73). There was no Group × Time interaction for the strength tests (p = .201 for 1-RM barbell bench press and p = .816 for the 1-RM barbell back squat, respectively). Dumbbells and FreeMotion machines were equally effective in improving strength in college-age females. The findings add to the literature on FreeMotion machines and benefit novice resistance trainers, physical educators, and fitness professionals. The study should be replicated with additional populations.

Resistance training is an effective method for various populations to develop muscular strength. Although free weights are considered the preferred mode of strength training, the development of various weight machines has extended the possible application of resistance training (Crone, 2011). In free weight exercise, the load being lifted remains constant throughout the range of motion. However, according to Crone (2011), the configuration of the joint causes the application of force to change at different points in that range of motion. A variety of weight machines have been designed in an attempt to match the resistance to potential force capability at different points in the range of motion to maximize the development of strength (McMaster, Cronin, & McGuigan, 2009).

Free weights are entirely controlled by the lifter and require the lifter to use synergistic muscles to control the weight throughout the range of motion (McCaw & Friday, 1994). To the contrary, weight machines guide the resistance through a specific path, reducing the activation by synergistic muscles (McCaw & Friday, 1994; Schick et al., 2010). A distinct manufacturer of resistance training machine called FreeMotion (FreeMotion Fitness, 2016) eliminates this fixed-path resistance. However, there is limited research on FreeMotion machines (Spennewyn, 2008). Similar to free weights, FreeMotion machines are controlled exclusively by the lifter and are capable of following an unrestricted range of motion. Dumbbell weights, in particular, are highly comparable to FreeMotion machines because, unlike the barbell or a traditional variable resistance training machine, these modes of training allow the lifter to hold the weight in each hand and perform exercises in a unilateral and unrestricted range of motion.

Because of the similarities in load application between dumbells and FreeMotion machines during the lifting range of motion, there is potential for comparable strength improvements throughout an individual's training. However, it is unclear if one mode of training is superior to the other regarding gains in strength (Langford, McCurdy, Ernest, Doscher, & Walters, 2007; Simpson, Rozenek, Garhammer, Lacourse, & Storer, 1997). With the increasing popularity of resistance training exercise, it would be advantageous to compare muscular strength gains among different strength training modes. Therefore, the purpose of this investigation was to examine the effects of different resistance training programs on the strength of untrained college-age females using dumbbell free weights and FreeMotion machines. It was hypothesized there would be no differences in strength gains between females in the two training methods.

Method

Participants

Participants were untrained females (no resistance training within past year) between the ages of 18 and 28 years who volunteered to participate in the study. To participate, the women had to be free from any chronic diseases such as coronary heart disease, diabetes, lung disease, or orthopedic problems that could prevent their participation. Pregnant women could not participate in the study. Additionally, the women had to have a BMI of less than 30 kg/m^2 to be eligible to participate. Participants consisted of female undergraduate and graduate students recruited from a university in the southeastern United States. The study was approved by the university institutional review board. All participants completed and signed an informed consent agreement form after having the risks and benefits of the study explained to them. Participants also completed and signed a Physical Activity Readiness Questionnaire (PAR-Q; Canadian Society for Exercise Physiology, 2002) and an American College of Sports Medicine (ACSM, 2014) health history form prior to participating in the study.

Procedures

The research was conducted in the summer and fall of 2015. There were two waves of recruitment. The summer participants were

recruited through a flyer that was e-mailed to all university students and faculty and staff members. The flyer was also posted in several areas on the university's campus. The information printed on the flyer informed the future participants of inclusion criteria for participation in the study. In the fall, participants were recruited from the university's weight training classes. These students must have also met the inclusionary criteria to participate.

The researchers then randomized participants into either a dumbbell group or a FreeMotion training group by selecting their ID numbers out of a hat. The participants self-selected two nonconsecutive days throughout each of the 8 weeks on which to train. In addition, the participants were free to choose what time they trained on each of the days. After selecting their days and times, they were asked to stay consistent with those days and times each week. The participants were also required to agree to refrain from engaging in any other weight training exercises during the 8 weeks of the study.

Prior to the start of the study, the participants' height, weight, BMI, and waist circumference were measured. They were also assessed on their one-repetition maximum (1-RM) barbell bench press and 1-RM barbell back squat prior to beginning the 8-week progressive strength training program. The ACSM 1-RM protocol was used to obtain maximal strength (ACSM, 2014). Throughout the 8-week strength training period, the dumbbell group followed a progressive strength training program using only dumbbells. The FreeMotion group followed a nearly identical program using only FreeMotion machine weights. Each participant had her own file, which contained her workout program. The participants were given an identification number, which was printed on the outside of their files. The participants were instructed to record their weights for each set of the exercises performed.

To track participant attendance, the researcher provided a sign-in sheet located at the front desk of the facility. The participant was instructed to sign in and record the time she began training each day of each week. She was also instructed to sign out when she had completed her training session for that day. A new sign-sheet sheet was provided at the end of each week. The researcher collected the sign-in sheets at the end of every week throughout the study. The researcher stayed in contact with each participant via e-mail or text

messaging to provide encouragement and to make sure the participants were performing their workouts.

For the first week of the study, a researcher was present for all of the participants' workout sessions to ensure that they were performing each exercise correctly and to answer any questions regarding the workout program. After the first week, the participants performed the workouts on their own, without supervision. However, the lead researcher performed random spot checks to ensure that the participants were performing their workouts correctly. The dumbbell and FreeMotion groups trained twice per week. The workout session for Day 1 (Workout A) of each week consisted of total body exercises (squats, chest press, lunges, shoulder press, chest fly, reverse fly, bicep curls, and triceps extensions). The workout session for Day 2 (Workout B) included the same exercises in a different order. The rest time in between each exercise and the tempo of each exercise was identical for the dumbbell and FreeMotion groups. The only difference between the training programs for the two groups was that the dumbbell group trained only using dumbbells and the FreeMotion group trained using only the FreeMotion machines. Table 1 shows examples of the first week's Workout A programs for both groups. The workouts progressed in intensity every 2 weeks with lower repetitions and longer rest breaks over the 8-week study. In the final weeks, participants performed 4 sets of 5–6 repetitions with 2.5 min rest between sets. Immediately following the 8-week period, both groups were reassessed on their 1-RM barbell bench press and 1-RM barbell back squat. The participants' weight, BMI, and waist circumference were also measured.

Data Analyses

The changes in strength gains observed among females in the resistance training modes were analyzed and interpreted using SPSS version 22 (IBM Corporation, Armonk, NY). The alpha level was set at $p < .05$. Descriptive statistics were calculated on the participants' age, height, weight, BMI, and waist circumference. A repeated measures ANOVA determined the differences in strength between the dumbbell and FreeMotion groups. The mean and standard deviations for the 1-RM for both groups were inserted into Cohen's *d* calculator, which determined the effect size of strength improvements (Soper, 2016).

Table 1
Week 1 Resistance Training Workout A for Dumbbell and FreeMotion Training

Dumbbell exercise	FreeMotion exercise	Sets	Repetitions	Tempo s	Rest s
DB squat	Two leg squat	2	8–10	4–2	60
DB incline chest press	Two arm incline chest press	2	8–10	4–2	60
DB lunges	Lunges	2	8–10	4–2	60
DB seated shoulder press	Two arm seated shoulder press	2	8–10	4–2	60
DB chest fly	Two arm chest fly	2	8–10	4–2	60
DB reverse fly	Two arm reverse fly	2	8–10		
DB alternating bicep curl	Alternating arms bicep curl	2	8–10	4–2	60
DB standing overhead triceps extension	Standing overhead triceps extension	2	8–10	4–2	60

Note. DB = dumbbell. Tempo is number of seconds in concentric and eccentric phase of lift.

Results

This study consisted of 18 untrained women between the ages of 18 and 28 years who completed the study. Participants were randomly assigned to a dumbbell or FreeMotion resistance training group. Both groups began the study with 10 participants; however, two participants from the dumbbell group dropped out of the study. One participant failed to complete the study because of the development of a health condition that was unrelated to the study, and the other participant moved away. Both groups followed a nearly identical progressive strength training program for 8 weeks. The groups were assessed pre- and posttest on 1-RM barbell bench press and 1-RM barbell back squat. The 18 participants who remained completed 97% of the study workouts.

Participant Characteristics

Table 2 presents participants' descriptive statistics for age, BMI, and waist circumference. The mean age of all participants was 20.5 (SD = 3.0) years. Following the 8-week study, there were no significant changes over time in their BMI, $F(1, 16) = .351$, $p = .922$, or waist circumference, $F(1, 16) = .478$, $p = .529$.

Table 2
Participant Characteristics

Characteristic	Dumbbell (n = 10) M (SD)	FreeMotion (n = 8) M (SD)	p (time)
Age (years)	20.8 (3.0)	20.3 (3.0)	
Pre-BMI (kg/m²)	24.0 (3.5)	23.1 (1.8)	
Post-BMI (kg/m²)	24.1 (3.2)	23.3 (1.9)	.351
Pre-WC (cm)	80.7 (7.7)	78.3 (6.7)	
Post-WC (cm)	79.2 (9.1)	78.2 (6.6)	.478

Note. WC = waist circumference.

1-RM Barbell Bench Press

A repeated measures ANOVA compared the 1-RM barbell bench press and 1-RM barbell back squat values between groups. A significant effect was found in both groups over time, $F(1, 16) = 57.086$, $p < .001$, for the 1-RM barbell bench press (Table 3). However, no significant Group × Time interaction was found between the dumbbell and FreeMotion groups, $F(1, 16) = 1.778$, $p = .201$. This supports the hypothesis that no significant differences in upper body strength gains between dumbbell and FreeMotion groups would be found. The mean overall strength gain for the 1-RM barbell bench press was 12% (SD = 7.9, range = 5–38).

Mean values and standard deviations of 1-RM barbell bench press and 1-RM barbell back squat of both groups were inserted into Cohen's d effect size calculator (Soper, 2016), which determined the effect size of the 8-week strength training program. Cohen's effect size value was $d = 0.56$ was for the 1-RM barbell bench press, which suggests a moderate effect size in upper body strength gains.

1-RM Barbell Back Squat

Table 3 shows the comparison of 1-RM barbell back squat values between groups. A significant effect was found in both groups over time, $F(1, 16) = 89.118$, $p < .001$, for the 1-RM barbell back squat. Like the 1-RM barbell bench press, the 1-RM barbell back squat between the dumbbell and FreeMotion groups had no Group × Time interaction, $F(1, 16) = .056$, $p = .816$. These data support the hypothesis

that no significant differences in lower body strength gains between dumbbell and FreeMotion groups would be discovered. The mean overall strength gain for the 1-RM barbell back squat was 20% (*SD* = 11.7, range = 7–38). For the 1-RM back squat, Cohen's effect size value was *d* = 0.73. This indicates a moderate to large effect size in lower body strength gains for both modes of training.

Table 3
Pre- and Post-1-RM Strength Values Between Dumbbell and FreeMotion Groups

Exercise	Dumbbell (*n* = 10) *M* (*SD*)	FreeMotion (*n* = 8) *M* (*SD*)	*p* (time)	*d*
Pre-1-RM Barbell Bench Press (kg)	33.0 (9.5)	35.9 (7.7)		
Post-1-RM Barbell Bench Press (kg)	37.5 (9.1)	39.1 (7.8)	< .001	0.56
Pre-1-RM Barbell Back Squat (kg)	57.1 (14.0)	58.1(16.0)		
Post-1-RM Barbell Back Squat (kg)	67.0 (12.0)	68.6 (15.0)	< .001	0.73

Note. There was no Group × Time interaction (p = .201 for 1-RM barbell bench press and p = .816 for the 1-RM barbell back squat).

Discussion

The purpose of this study was to investigate the effects of different resistance training programs on strength of untrained college-age females using free weights and FreeMotion machines. The key finding in this study is that participants in both programs had significant improvements in strength over time, but there were no significant differences in strength gains between dumbbells and FreeMotion machine groups.

Primarily, past research has not reported significant differences over time in strength gains among people using different strength training modes (Ben-Sira, Ayalon, & Tavi, 1995; Boyer, 1990; Mayhew, Smith, Arabas, & Roberts, 2010). The results in this study concur with these findings. However, other studies have indicated that people may improve strength faster using machine weights versus free weights (Crone, 2011; Lennon, Mathis, & Ratermann, 2010; Mayhew et al., 2010). Also, there is support within the literature that improvements in strength are greater for people using free weights (Saeterbakken, Tillaar, & Fimland, 2011). Overall, previous litera-

ture regarding strength superiority among different resistance training modes has produced mixed findings.

An explanation for unclear findings on this topic could be that the specific exercises included in the programs for each group were inconsistent. Previous research has indicated similar exercises were included for each of the training programs (Anderson, Sforzo, & Sigg, 2008; Boyer, 1990; Colado et al., 2010; Lennon et al., 2010; Meek, Van Horn, & Schafer, 2008; Spennewyn, 2008). However, the exercises may not have been completely uniform for both groups. One mode of training may have led to superior strength gains in participants due to greater muscle activation during one or more specific exercises. In this study, the exercises were identical for the dumbbell and FreeMotion groups. The exercises in this study also progressed equally in sets, repetitions, rest time in between exercises, and tempo. None of the previous studies discussed the tempo of their exercises. Tempo is an important factor to include in a resistance training program because it prescribes the speed of each repetition (Sutton, 2012). If two or more groups perform the same exercises but with different tempos, they may observe differences in strength improvements.

The modes of resistance training that were compared served as a key strength of this study. Because of the similarities in load application and range of motion between dumbbells and FreeMotion machines, there was potential for comparable strength gains throughout participants' training. Both types of resistance training are controlled exclusively by the lifter and are capable of following an unrestricted range of motion. Also, the dumbbell and the FreeMotion machine allow the lifter to hold the resistance in each hand and perform exercises unilaterally if desired. Previous studies may have observed significant differences in strength gains because they compared modes of training that were dissimilar in load application (Cacchio et al., 2008; Saeterbakken et al., 2011)

The use of 1-RM testing on a barbell was another strength of this study. Because one group performed all of its exercises with dumbbells and the other used the FreeMotion machine, the barbell provided an unbiased method for testing each group's upper and lower body strength. If the study had included barbell exercises in the free weight group, the free weight group may have observed greater strength gains due to familiarization with the testing equipment.

Limitations were also present in this study. The participants may not have given their best effort on every workout day or on the 1-RM testing days due to their untrained status. An additional limitation to the study is that the participants may not have completed the workouts the way they were designed to be completed. The participants performed the workouts on their own, without supervision, although random spot checks were performed. Therefore, some participants may not have gone through the exercises properly with the correct number of sets, reps, rest time, or tempo. Participants may have tested significantly better after the 8-week period due to familiarization with the testing equipment and with how to perform a bench press and squat. No control group performed only the testing and no training, so there was no way to eliminate a testing effect. Videos were not recorded and electromyographic (EMG) analyses of the exercise sessions were not used in the study to verify muscle activation or range of motion.

Conclusion

The findings in this investigation are beneficial to strength and conditioning coaches, personal trainers, and other fitness enthusiasts who desire to obtain optimal improvements in strength. Training with the FreeMotion machine was found to be equally advantageous to training with dumbbell weights in terms of strength gains among untrained females. Physical educators, fitness trainers, or coaches who have untrained students, untrained clients, or athletes utilize FreeMotion machine exercises in place of dumbbell exercises may observe nearly identical strength improvements. Also, no injuries were reported for either group throughout the study. This study showed that if coached correctly with proper form, a progressive strength training program with either dumbbells or FreeMotion machines is safe for the participant. This study also added to the body of literature on resistance training with FreeMotion machines.

Because of the equivocal research findings regarding the superiority among strength training modes, continued research is needed. Further research is also needed on the FreeMotion machine. Furthermore, prospective studies should address tempo of exercises and rest time in between exercises. Including a larger sample size in future research designs would also assist in replication of results. This study utilized college-age participants, as is common in other studies

(Bellar et al., 2011; Boyer, 1990; Cotterman, Darby, & Skelly, 2005; Floyd, Otte, & Mayhew, 2009; Lyons, Mclester, Arnett, & Thomas, 2010; Saeterbakken et al., 2011). Inclusion of other age groups such as youth, middle-aged adults, or older adults would be important for future research studies.

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