EFFECT OF STRENGTH GAIN ON UPPER BODY: SMITH MACHINE VS FREE WEIGHTS

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ABSTRACT
The aim of this study is to compare upper extremity strength gain between multi-push machines and free weights in individuals with a sedentary lifestyle who go to sports centers to work out. Based on the obtained results, the machine efficiency and the best way to increase upper extremity strength can be deduced. Twenty-two individuals between the ages of 18 and 53 (29.04±10.55), without any health problems and a background in sports, participated in our study. The participants were divided into two groups: the Free Weight study group and the Smith Machine study group. The measured parameters of the participants were height, weight, flexibility, back strength, hand grip strength, and muscle strength, with the latter being done thrice per participant, and the highest value being chosen as the relevant value. In this study, statistically significant differences were found between the pre- and post-testing values of the two groups ($p < .05$). When the two groups were compared with each other based on the post-test values, no statistically significant differences were found ($p > .05$). Nevertheless, the difference between pre- and post-testing values yielded a 1.25 average strength gain for Smith Machine study group and 2.36 average strength gain for Free Weight study group.

Keywords: *resistance training, muscle activation, sedentary lifestyle, neuromuscular adaptation, anthropometric assessment*

INTRODUCTION

Sadly, nowadays, many people lead sedentary and monotonous lives. Lack of movement is one of the most harmful conditions for humans and leads to various diseases. Immobility affects the entire body, causing muscle loss, impaired neuromuscular coordination, and reduced joint mobility. These changes negatively impact quality of life, especially with age (Özdilek & Kılıç, 2006). Muscle strength, defined as the maximum force a muscle can exert, is crucial for maintaining a high quality of life. Muscle strength is proportional to its cross-sectional area (Akgün, 1994). There is also a positive correlation between muscle strength and the quantity and radius of cross-sectional fibrillae (Kalyon, 1997). Some studies report a correlation between neural development and muscle strength and performance capacity (Wilmore et al., 1998). Since regular physical activity is associated with better health and mobility, promoting exercise increases overall public health (Ocak & Güdül, 2008). Encouraging people to exercise in well-equipped gyms with high-quality services can help make physical activity a regular part of life and prevent discouragement.

In addition to free weights, such as barbells and kettlebells, gyms also offer various machines designed to guide movements along specific angles and axes. One of the most widely used is the Smith Machine, which enables vertical movement along rails and includes safety features. This makes it popular among beginners. Fixing the movement angle limits the role of stabilizing muscles, increasing the load on the target muscles. In their study, Schick et al. compared bench press exercises using the Smith Machine and a free barbell (Schick et al., 2010). The results obtained indicated higher activation of the lateral deltoid muscle group in the group that exercised with the Smith Machine. Since the free barbell used during bench press exercises has longitudinal freedom of movement, the lateral deltoid muscle group works to stabilize the weight. A lack of movement in the Smith Machine decreases the workload of this muscle group and, as a result, promotes higher activation in the target muscle group.

Aim and Objectives

This study aims to compare the upper extremity strength gains of sedentary individuals who engage in physical activity using either multi-push machines or free weights. The goal is to determine whether machines or free weights are more ben-

eficial. Based on the results, we will evaluate the effectiveness of machine training and identify the more effective method for improving upper extremity strength. We will compare the two groups to determine whether training with free weights or machines yields better outcomes. Changes in participants will be monitored through anthropometric assessments and measurements of upper extremity, handgrip, and back strength.

METHODOLOGY

Data analysis was done using the SPSS 21.0 package program, under which the Two-Independent Samples *t*-Test and Paired Samples *t*-Test were used. A Bonferroni correction was applied (adjusted $\alpha = .01$) to control for family-wise error and reduce the likelihood of Type I errors across multiple pairwise comparisons.

1st group in our study (Free Weight Study Group, FWG) consisted of 11 individuals; 7 men and 4 women, with an average age of 27.54±12.11, height, 175.45±7.84 cm, weight, 68.95±14.04 kg.

2nd group in our study (Smith Machine Study Group, SMG) consisted of 11 individuals; 8 men and 3 women, with an average age of 30.54±9.07, height, 173.45±12.23 cm, weight, 75.37±16.70 kg.

Participants were asked to perform the following exercises 3 days per week (Monday, Wednesday, and Friday) for 8 weeks:

- Warm-up walk for 10 mins at 6.0 kph speed and 0% inclination.
- Jumping Jack. 2 sets, 20 reps.
- Seal Jack. 2 sets, 20 reps.
- Group 1 – Bench Press (free weight with bar), Group 2 – Bench Press (Smith Machine). 4 sets, 10 reps.
- Group 1 – Biceps Curl (free weight with bar), Group 2 – Biceps Curl (Smith Machine). 4 sets, 10 reps.
- Cool-down walk for 10 mins at 6.0 kph speed and 0% inclination.

For exercises that do not use body weight, exercise weight for each individual was determined as half of the maximum strength per repetition, which was measured using a strength measurement device. During these measurements, no extra opposing force was applied to the individuals through the measuring device, and the individuals were asked to exert force onto the device until exhaustion. The obtained peak strength value was taken as a basis. Weights and intensities remained unchanged during the study period of 8 weeks. Because the intensity was taken as half of the maximum measured strength, rest time between sets was taken as 1 minute. The reason for giving a 1-minute rest period is that 80-85% of the ATP-CP energy source is recovered in 1 minute. (Harris et al., 1976)

This study measured strength gain objectively using the Geratech SH-1000 digital dynamometer. The Geratech SH-1000 digital dynamometer is a handheld force measurement device designed for both tension and compression testing. It is manufactured by Geratech and offers a maximum capacity of 1000 N with a resolution of 1 N. The instrument provides high accuracy (±0.5%) and supports multiple units, including N, kgf, and lbf. It features Peak/Track modes, data storage, and an RS-232C interface for data transfer to a computer. The device operates on a rechargeable battery and is widely used for quality control and material testing applications. Flexibility was assessed using a sit-and-reach box (Baseline Sit and Reach Trunk Flexibility Box, Fabrication Enterprises Inc., White Plains, NY, USA). The measurement range was 0–50 cm, with 0.5 cm precision.

RESULTS

A statistically significant difference was found between pre- and post-testing in hand grip strength, bench press strength, elbow flexion strength and flexibility measurements in FWG ($p < .05$).

Table 1. *Within-Group Differences in the Free Weight Group (FWG)*

Parameters	Pre-Test (*Mean*±*SD*)	Final Test (*Mean*±*SD*)	*p*
Hand Grip Dominant Strength (kg)	42.19 ± 10.73	43.46 ± 10.67	.001
Hand Grip Non-Dominant Strength (kg)	40.60 ± 10.97	42.34 ± 11.07	< .001
Strength Measurement Bench Press (kg)	45.25 ± 10.44	46.99 ± 10.90	.001
Elbow Dominant Flexion Strength Measurement (kg)	19.90 ± 5.83	21.49 ± 6.07	< .001
Elbow Non-Dominant Flexion Strength Measurement (kg)	19.13 ± 5.73	20.42 ± 6.02	.010
Back, Leg Strength (kg)	101.42 ± 23.16	103.01 ± 23.56	.240
Flexibility Measurement (cm)	3.00 ± 10.44	4.54 ± 9.92	.036

A statistically significant difference was found between pre- and post-testing values in hand grip non-dominant strength, bench press strength, Smith Machine elbow flexion strength, and flexibility measurements in SMG ($p < .05$).

Table 2. *Within-Group Differences in the Smith Machine Group (SMG)*

Parameters	Pre-Test (*Mean±SD*)	Final Test (*Mean±SD*)	*p*
Hand Grip Dominant Strength (kg)	43.18±13.70	43.53±13.11	.501
Hand Grip Non-Dominant Strength (kg)	41.98±14.57	43.21±14.24	.019
Strength Measurement Smith Machine (kg)	49.37±10.43	50.85±9.94	< .001
Elbow Dominant Flexion Strength Measurement (kg)	21.96±6.44	23.21±6.58	< .001
Elbow Non-Dominant Flexion Strength Measurement (kg)	21.59±6.34	23.18±6.42	< .001
Back, Leg Strength (kg)	115.51±35.63	115.60±31.08	.971
Flexibility Measurement (cm)	6.81±6.17	7.54±6.48	.087

No statistically significant difference was found between FWG and SMG in hand grip strength, bench press strength, elbow flexion strength, back and leg strength, and flexibility pre-testing measurements ($p > .05$).

Table 3. *Pre-Test Between-Group Differences Between the Free Weight (FWG) and Smith Machine (SMG) Groups*

Parameters	Pre-Test (*Mean±SD*)	Final Test (*Mean±SD*)	*p*
Hand Grip Dominant Strength Pre-Test (kg)	42.19±10.73	43.18±13.70	.852
Hand Grip Non-Dominant Strength Pre-Test (kg)	40.60±10.97	41.98±14.57	.806
Strength Measurement Pre-Test (kg)	45.25±10.44	49.37±10.43	.366
Elbow Dominant Flexion Strength Measurement Pre-Test (kg)	19.90±5.83	21.96±6.44	.442
Elbow Non-Dominant Flexion Strength Measurement Pre-Test (kg)	19.13±5.73	21.59±6.34	.352
Back, Leg Strength Pre-Test (kg)	101.42±23.16	115.51±35.63	.285
Flexibility Measurement Pre-Test (cm)	3.00±10.44	6.81±6.17	.309

No statistically significant difference was found between FWG and SMG in hand grip strength, bench press strength, elbow flexion strength, back and leg strength, and flexibility post-testing measurements ($p > .05$).

Table 4. *Post-Test Between-Group Differences Between the Free Weight (FWG) and Smith Machine (SMG) Groups*

Parameters	Pre-Test (*Mean±SD*)	Final Test (*Mean±SD*)	*p*
Hand Grip Dominant Strength Final Test (kg)	43.46±10.67	43.53±13.11	.989
Hand Grip Non-Dominant Strength Final Test (kg)	42.34±11.07	43.21±14.24	.874
Strength Measurement Final Test (kg)	46.99±10.90	50.85±9.94	.396
Elbow Dominant Flexion Strength Measurement Final Test (kg)	21.49±6.07	23.21±6.58	.530
Elbow Non-Dominant Flexion Strength Measurement Final Test (kg)	20.42±6.02	23.18±6.42	.312
Back, Leg Strength Final Test (kg)	103.01±23.56	115.60±31.08	.297
Flexibility Measurement Final Test(cm)	4.54±9.92	7.54±6.48	.411

Table 5. *Pre- and post-testing value difference comparison between Free Weight (FWG) and Smith Machine (SMG) study groups*

Parameters	FWG	SMG
Hand Grip Dominant Strength (kg)	1.27	0.35
Hand Grip Non-Dominant Strength (kg)	1.74	1.23
Strength Measurement Smith Machine (kg)	1.74	1.48
Elbow Dominant Flexion Strength Measurement (kg)	2.36	1.25
Elbow Non-Dominant Flexion Strength Measurement (kg)	1.29	1.59
Back, Leg Strength (kg)	1.59	0.009
Flexibility Measurement (cm)	1.54	0.73

Although there is no statistically significant difference between the groups in terms of strength gain, when compared to SMG, the difference between pre- and post-testing values for FWG indicates an increase in value for all but one parameter. It was observed that FWG had an increase of 1.27 in hand grip dominant strength, whereas this value remained around 0.35 for SMG. The bench press exercise showed a strength gain of 1.74 for FWG, whereas it was 1.48 for SMG. Elbow dominant strength gain for FWG was 2.36, whereas it remained 1.25 for SAG. Elbow non-dominant strength gain for FWG was 1.29, whereas it was 1.59 for SMG. Back strength gain for FWG was 1.59, whereas it was 0.009 for SMG. Flexibility gain for FWG was 1.54, whereas it was 0.73 for SMG.

DISCUSSION

The present study investigated the effects of free weight and Smith Machine exercises on upper extremity strength in individuals without a sports background. Both groups showed improvements in grip, flexion, back, and leg strength, with the Free Weight Group (FWG) demonstrating greater gains overall. These findings align with previous studies emphasizing the effectiveness of resistance training in increasing muscle strength (Taaffe et al., 1999; Laforest et al., 1990). Similar to the results of Taaffe et al. (1999), who reported significant improvements in muscle strength across different training frequencies, participants in both groups of the present study experienced measurable increases in strength, regardless of the exercise type. The more pronounced strength gains observed in the FWG are consistent with those reported by Schwanbeck et al. (2009), who found higher muscular activation during free-weight squats compared to Smith Machine squats. This supports the idea that the additional stabilization and balance required in free weight exercises recruit more muscle fibers and enhance neuromuscular coordination. Likewise, the higher bench press strength recorded in the FWG parallels the findings of Cotterman et al. (2005), who found that maximum bench press strength was significantly greater in free-weight users than in Smith Machine users. The reason for this similarity likely lies in the need to stabilize the bar during free weight exercises, which increases both muscle activation and grip strength — a relationship also observed in our participants, whose dominant hand grip strength improved notably in the FWG. However, the observation that the Smith Machine Group (SMG) showed greater improvements in non-dominant elbow flexion strength diverges slightly from findings in earlier studies. Schick et al. (2010) and Saeterbakken et al. (2011) found no significant differences in pectoralis major or deltoid activation between Smith Machine and free-weight exercises. However, they reported greater activation in stabilizing muscles during free-weight training. The current study suggests that, for untrained individuals, the fixed bar path of the Smith Machine may help distribute effort more evenly between dominant and non-dominant sides, explaining this partial discrepancy. This aligns with Saeterbakken et al. (2011), who noted that prior training experience can influence muscle activation patterns during resistance exercises. Additionally, increases in back and leg strength in both groups support the findings of Laforest et al. (1990), who reported improved lower limb strength with consistent physical activity. The slightly greater improvements in the FWG may result from a higher activation of the posterior chain muscles during free-weight lifts, as Schwanbeck et al. (2009) also observed. These results collectively indicate that while Smith Machine exercises provide stability and safety—especially important for beginners or individuals with joint concerns—free weight exercises yield superior neuromuscular adaptation and overall strength development. In summary, the results of the present study corroborate previous research, showing that free-weight exercises engage a broader range of muscles and produce greater overall strength gains, whereas Smith Machine exercises are advantageous for controlled, single-plane movements and injury prevention. The observed differences between the two modalities may stem from biomechanical variations: free weights require stabilization across multiple planes. At the same time, Smith Machine exercises confine movement to a single axis, reducing variability and load asymmetry. These findings contribute to the growing body of evidence (Cotterman et al., 2005; Schwanbeck et al., 2009; Schick et al., 2010; Saeterbakken et al., 2011) suggesting that both exercise types can be beneficial, with free weights being more effective for comprehensive strength enhancement and Smith Machines offering a safer alternative for untrained individuals.

CONCLUSION

In this study, height, weight, flexion, back strength, hand grip strength, and muscle strength

were measured in 22 participants without a background in sports. The results are as follows: Pre- and post-test values of dominant and non-dominant hand grip strength increased in both groups, with a more pronounced increase in the Free Weight Group (FWG). This is likely due to the greater movement freedom in free-weight exercises, which require a stronger grip to maintain balance and enhance hand grip strength. Bench press strength increased in both groups, but was higher in FWG, possibly due to greater muscle activation from balancing muscles and slight angular variations activating surrounding muscles. Elbow flexion strength comparisons showed higher dominant arm gains in FWG, while the Smith Machine Group (SMG) showed higher increases in the non-dominant arm. This may be explained by FWG's freedom of movement, causing the dominant arm to bear more load, whereas SMG's stable single-axis movement distributes load more evenly. Back and leg muscle strength increased in both groups, with greater gains in FWG, possibly due to higher back muscle activation during free-weight exercises. Although initial strength gain differences seem small, they may become significant over time. FWG showed a strength gain of 2.36 compared to 1.25 in SMG, and this gap is expected to widen with continued training. The difference likely results from the extra muscular effort in free weight exercises to prevent lateral weight movement, absent in SMG's fixed path. Based on the findings of the present study, the Free Weight Group (FWG) proved to be more effective for overall upper extremity strength development, as reflected by greater increases in hand grip, bench press, and back strength. In contrast, the Smith Machine Group (SMG) was found to be more advantageous for controlled single-axis movements and may therefore be suitable for individuals recovering from or prone to joint injuries. These outcomes suggest that, for participants without prior sports experience, free-weight exercises are particularly beneficial in the early stages of training, improving grip strength and enhancing muscle coordination. Moreover, the greater back strength observed in the FWG, even though the back muscles were not the primary focus, suggests that free-weight exercises promote secondary muscle activation due to the need for stabilization. Overall, the results of this study demonstrate that the biomechanical characteristics of free-weight exercises, which require stabilization across multiple joints and planes, contribute directly to broader strength gains. In contrast, the fixed path of the Smith Machine limits movement variability but reduces joint stress, making it a safer option for targeted or rehabilitative exercise programs. Proper technique and warm-up exercises are recommended for safety and effectiveness. This study shows free weight barbell curls suit dominant elbow flexion strength gain, whereas Smith Machine curls are better for the non-dominant arm. FWG is efficient for overall upper extremity strength gain, while SMG is suited for controlled single-axis exercises.

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