Electromyographical Comparison Between a Digital Weight and Traditional Free Weights

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Abstract

PURPOSE: The purpose of this study was to compare muscle activation during various exercises performed using a digital weight system and traditional free weights. METHODS: Healthy adults (26 ± 7 yrs.) participated in this study. Prior to the experimental conditions, a predicted one-repetition maximum (1RM) for each of the exercises was determined on the digital weight system (DWS). Visits 2-3 composed the experimental conditions in random order, traditional free weight (FREE), and DWS. During each experimental condition participants performed, in random order, 1 set of 9 repetitions of three separate exercises, bicep curls, skull crushers, and standing overhead shoulder press. Five minutes of rest was provided between each exercise to minimize the effect of fatigue. During the DWS condition, the digital weight system (Tonal© Home Gym©, San Francisco, California) was set to dynamic load. During dynamic load, the load was 65% of 1RM at the transition from eccentric to concentric phases and the load increased during the concentric phase and decreased during the eccentric phase. The FREE condition was performed at 65% 1RM. During all exercises, surface electromyography (EMG) were placed on the biceps brachii, triceps, and anterior deltoid in accordance with Surface Electromyography for the Non-Invasive Assessment of Muscles (SENIAM) recommendations. Prior to each experimental condition participants performed two maximal voluntary isometric contractions (MVIC) for each muscle under investigation, for EMG normalization. All EMG was normalized to the respective MVIC and therefore all EMG values are expressed as a percentage of MVIC. For each condition and exercise, repetitions 4, 5, and 6 were analyzed and averaged to provide a mean for each condition and exercise. T-test was utilized to assess differences. RESULTS: No differences in bicep brachii muscle activation were observed between the DWS and FREE during the bicep curl exercise (DWS = 36.39 ± 18.26 %MVIC, FREE = 27.68 ± 7.39 %MVIC, p = 0.35). Triceps muscle activation was not different between the DWS and FREE during the skull crusher exercise (DWS = 24.76 ± 4.32 %MVIC, FREE = 23.79 ± 9.19 %MVIC, p = 0.84). DWS and FREE resulted in similar muscle activation of the anterior deltoid during the standing overhead shoulder press (DWS = 41.34 ± 3.13 %MVIC, FREE = 36.98 ± 7.03 %MVIC, p = 0.24). CONCLUSIONS: In the current investigation no differences in muscle activation were observed between free weight exercise and a digital weight system in the primary movers during the investigated exercises. PRACTICAL APPLICATIONS: Given the similar levels of muscle activation observed it appears that the digital weight system and free weights result in similar muscle stress despite the variable nature of the digital weight. These acute responses suggest that either the digital weight system or traditional free weights could provide an effective training stimulus.

Background

- The Tonal© is a digital weight system designed for at-home use. The Tonal© features unique exercise modes such as Smart Flex. Smart Flex utilizes the digital weights system to intelligently match the resistance to the exerciser by continuously adding or subtracting weight depending on when their muscles are at their strongest and weakest during an exercise.
- This unique exercise mode, results in the resistance being variable through the range of motion when exercising with the Tonal©, which is different compared to traditional free-weight exercises.
- Variable resistance training methods have been shown to improve the rate of force development, coordination between antagonist and synergist muscles, the recruitment of motor units, and reduce the drop in force produced in the sticking region of lifts (1).
- Electromyography (EMG) is used to measure the electrical signals within the muscle by placing electrodes on the skin over the muscle belly of interest. Skeletal muscle consists of several motor units which enable the grading of force generation. For example. when we lift a heavy weight, it requires our muscles to recruit more motor units to be able to produce the necessary force to lift that weight. When each motor unit is recruited it results in an electrical signal being sent to the muscle. This electrical signal is known as an action potential (2).
- The EMG signal is based upon action potentials at the muscle fiber membrane resulting from depolarization and repolarization processes

Purpose and Hypothesis

The purpose of this study was to compare muscle activation during various exercises performed using a digital weight system and Tonal©.

We hypothesized that we would observe a difference in muscle activation between the two modes of exercise due to the variable nature of the Tonal©.

Methods

Participants

- Eight healthy adults (26 ± 7 yrs.) participated in this study. All participants completed three separate visits

Visit 1

- Participants first completed an informed consent and medical history questionnaire
- Next participants completed a one-repetition maximum (1RM) for the three exercises that were performed. Skull crushers were performed to target the triceps, standing overhead press targets the anterior deltoids, and bicep curls were performed to target the biceps.
    - 65% of their 1RM's were used during each condition (Tonal© or free weight)

Visit 2 and 3

- In this study, participants were randomized to determine which condition they would complete first
- Participants were first outfitted with surface EMG on the anterior deltoid, biceps brachii, and triceps.
- During each condition participants begin their exercise trials by completing maximal voluntary isometric contractions for each muscle under investigation. This was done in order to normalize the EMG data between conditions and participants.
- Next, in random order participants completed 9 repetitions of each exercise.
- In between each exercise, participants rested for 5 minutes to minimize the effect of fatigue on performance.

Data Analysis

- The EMG signal was collected at a frequency of 2000 Hz, bandpass filtered at 10-500 Hz, smoothed via root mean square (RMS), then normalized to MVICs.
- Repetitions 4, 5, and 6 were analyzed and used for comparisons between conditions.
- T-test was utilized to assess differences

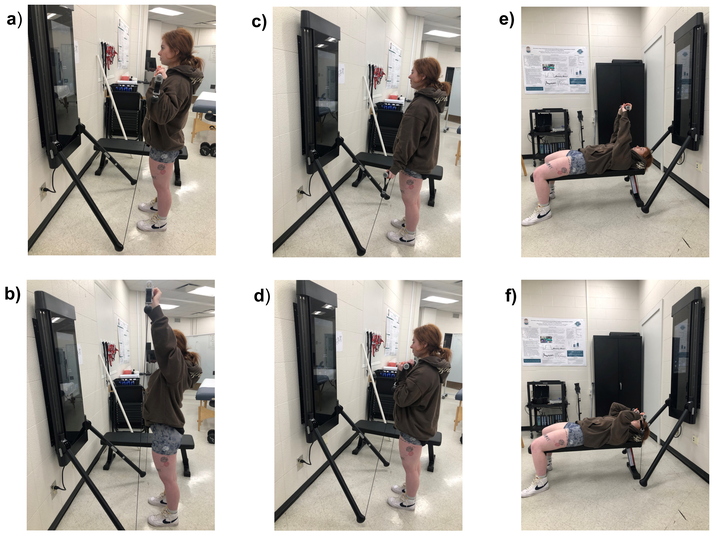

Figure 1. Representation of Tonal© exercises; a) starting position for standing overhead press, b) ending position standing overhead press, c) starting position bicep curl, d) ending position for bicep curl, e) starting position for skull crushers, f) ending position for skull crushers

References

1. Soria-Gila, Miguel A.; Chirosa, Ignacio J.; Bautista, Iker J.; Baena, Salvador; Chirosa, Luis J.. Effects of Variable Resistance Training on Maximal Strength: A Meta-Analysis. Journal of Strength and Conditioning Research 29(11):p 3260-3270, November 2015.
2. Larry Kenney, W., Jack H. Wilmore, and David L. Costill. 2020. Physiology of Sport and Exercise. 7th ed. Champaign, ILL: Human Kinetics.

RESULTS

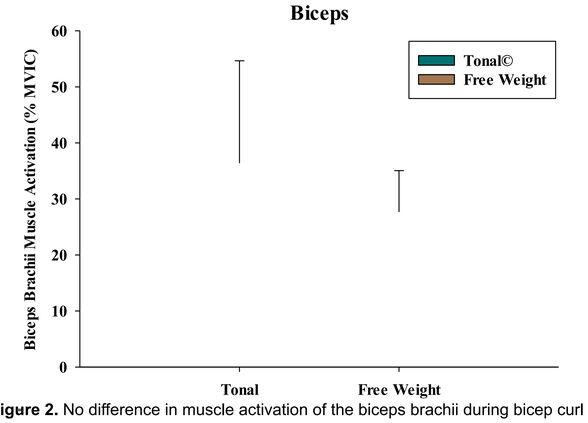

Figure 2. No difference in muscle activation of the biceps brachii during bicep curl

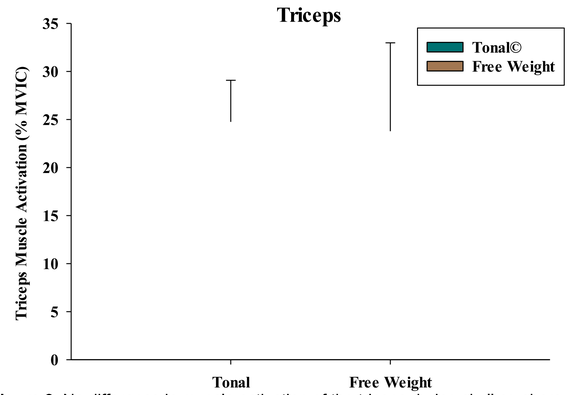

Figure 3. No difference in muscle activation of the triceps during skull crushers

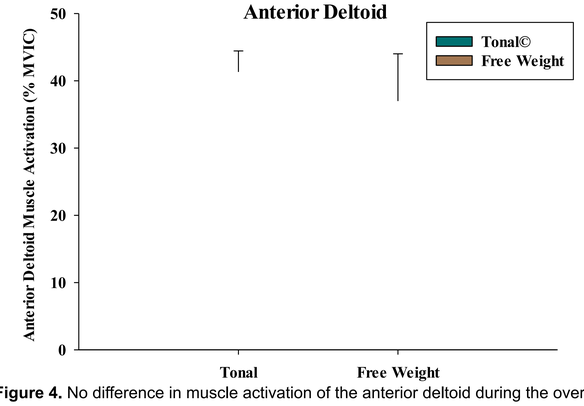

Figure 4. No difference in muscle activation of the anterior deltoid during the overhead press

Conclusion

In the current investigation, no differences in muscle activation were observed between free weight exercise and Tonal© in the primary movers during the investigated exercises.

Therefore, the Tonal© may be an effective home-based exercise modality, however, future research is needed to determine long-term training adaptations.