

MUSCLE ACTIVATION DURING WRIST FLEXION AND EXTENSION AGAINST A GYROSCOPIC RESISTANCE

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Introduction

The Dynasphere (Neurolink, Swarthmore, PA) is a hand held, 85mm diameter sphere weighing approximately 1 kg. Enclosed in the ball is a motorized gyroscope that consists of a weighted spinning wheel. When the wheel is spinning rapidly, due to the action of a small electronic motor, a given amount of angular momentum is contained in the wheel. Due to the conservation of angular momentum the gyroscope resists changes in its orientation and can provide resistance to movement and thus therapeutic exercise. In order to assess the potential benefits of exercise with this device the muscle activation occurring wrist flexion and extension were measured. Resisted wrist flexion and extension are common exercises for rehabilitating a variety of wrist injuries^{1,2}. The purpose of this study was to determine if any change in the muscle activity is provided by the gyroscopic effect of the Dynasphere.

Methods

Ten women and ten men, healthy and aged between 18 and 30 were recruited from the university student population. For participation, each subject was required to be free of any musculoskeletal condition that might put him or her at risk of injury from the testing or compromise his/her performance. Once the subject was asked to be involved in the research project, the risks, benefits and procedures of the testing were explained and they were asked to sign an institutionally approved informed consent document. When the Dynasphere is set to 0% activation it effectively behaves as a mass and its inertia and gravity force only provides the resistance. This was compared to the Dynasphere with the electric motor within the ball rotating at maximum speed and thus the gyroscopic resistance was as high as the device could generate. Subjects were seated with the elbow flexed at 90 degrees and the forearm supported in a horizontal position. The wrist was free to flex and extend. Each subject performed 4 repetitions of alternating wrist flexion and extension for each of the following conditions presented in a randomized and balanced order: 1) supinated, gyroscope off; 2) supinated, gyroscope on; 3) pronated, gyroscope off; 4) pronated, gyroscope on. Consistent speed of movement was maintained using a metronome set at 1 Hz. The electromyographic signals were amplified using BioPac pre-amplified electrodes and amplifier and recorded using a computer via analog to digital conversion. Two surface electrodes were placed on the forearm: 1) distal to the lateral epicondyle of the humerus on the wrist extensor muscle group; and 2) distal to the medial epicondyle on the wrist flexor muscle group. Prior to placement, the appropriate areas were shaved, lightly abraded with sand paper, and then wiped clean with alcohol. The signals were sampled at 500Hz and stored on hard disk for analysis. To quantify the amount of electromyographic activity the RMS value of the four repetitions was calculated for both the extensor and flexor muscle groups individually. Paired t-tests were used to determine if differences between the gyroscope on and off conditions were significant with Bonferroni correction of the initial alpha level of $p \leq 0.05$ to control for inflation of the experiment-wise error.

Results

Table 1. Ratios of gyroscope on versus off for EMG activity in the wrist flexors and extensors during flexion and extension movements.

Muscle Group	Movement	
	Flexion	Extension
Flexors	3.5(3.6)*	6.7(9.0)*
Extensors	10.7(16.4)*	2.7(2.8)

* indicates significant difference between the gyroscope on and off conditions $p \leq 0.05$

Discussion

This study was designed to assess the changes in muscle activation of the wrist flexor and extensor muscle groups between a control condition of simply lifting a given mass versus working against the resistance provided by a gyroscope. Muscle activity was between 3.5 and 10.7 times larger when the subject was required to move the ball against the gyroscopic stability effect. In particular, the gyroscopic resistance elicited relatively higher activity in the agonists when they were working with gravity. This indicates that the resistance was provided in both directions rather than opposing just the upwards movement when working against gravity alone. The meaningfulness of these results for strength training rehabilitation will have to be confirmed by future longitudinal training studies, however these preliminary results suggest gyroscopic stability may provide a useful form of resistance which is bi-directional. Further, the inherent resistance to rapid oscillation provided by the gyroscope may provide added benefits during exercise performance by patients with tremor e.g. Parkinsons disease.

References

1. Erwin, et al., *Arch Phys Med Rehabil.* 72:701-702, 1991.
2. Francisco, et al. *Arch Phys Med Rehabil.* 79:570-575, 1998.