TRUNK AND LEG MUSCLE EMG AND PERCEIVED EXERTION DURING RESISTED TRUNK ROTATION EXERCISE

[1,2]Kelly R. Marbaugh, [2]Vijay K. Goel, [2]David Dick, [1]Danny M. Pincivero
[1]Human Performance and Fatigue Laboratory, Department of Kinesiology, [2]E-CORE, Department of Bioengineering, The University of Toledo
Email: danny.pincivero@utoledo.edu

INTRODUCTION

Due to the high prevalence of low back pain in otherwise healthy adults (1), modalities designed to strengthen and condition the trunk muscles have been primarily limited to actions involving sagittal plane trunk movements. As axial trunk rotation is often cited as a contributory mechanism to low back injury, few devices currently exist to assist exercise-related development of trunk rotation strength. The objectives of the present study were to develop, and provide initial validation of, a working prototype exercise device designed to provide graded resistance to standing trunk rotation. The initial level of validation was obtained by examining trunk and leg muscle activation, via the electromyogram (EMG), and ratings of perceived exertion (RPE).

METHODS

Prototype development

A fourth generation working prototype device (patent pending, 2) designed to provide resistance to trunk and pelvic axial rotation is pictured in Figure 1. The device provides adjustable resistance to 2 independently controlled attachments that secure a user's upper trunk and pelvic regions, while the user in a weight bearing position.

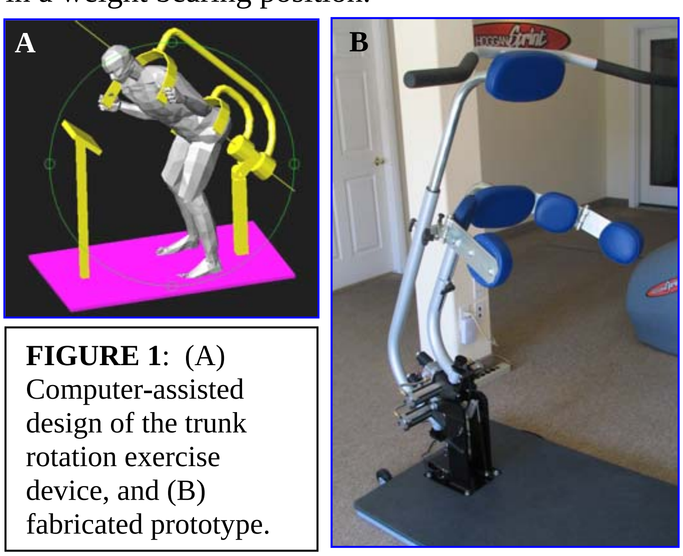

FIGURE 1: (A) Computer-assisted design of the trunk rotation exercise device, and (B) fabricated prototype.

The resistance to rotation is independently computer-controlled to the upper and lower attachments, and is provided by hydraulic linear actuators operating with a rack-and-pinion mechanism. The device was designed to provide 11 levels of resistance, in 1 point increments. Rotational potentiometers were embedded within the base of each rotational attachment, which allowed a total excursion of 140 degrees of rotation. The sagittal orientation of the resistance attachments was adjustable (continuous) from the upright position to 45 degrees of forward lean.

Human validation study

Seven healthy young adults (5 men, 2 women, 23.0 ± 3.4 years, 73.5 ± 8.4 kg, 174.2 ± 7.0 cm,) with no history of low back or lower leg injury, neurological or cardiopulmonary conditions participated in two evaluation sessions, separated by approximately 1 week. Subjects performed 3 full cyclical trunk rotations on the device at each of the 11 resistance levels (0-10), in a random order, at a set cadence (20 cycles per minute), with 2 minutes of rest separating each bout. During the exercise bouts, muscle EMG was recorded at 2000 Hz (20-500 Hz bandpass filtered via pre-amplified bi-polar bar surface electrodes (Delsys Inc.) from the following muscles, bi-laterally: rectus abdominis (RA), external abdominal oblique (EO), internal abdominal oblique (IO), paraspinal muscles at T9, L3, and L5, latissimus dorsi (LD), vastus medialis (VM), vastus lateralis (VL), rectus femoris (RF), medial hamstring (MH), adductors (AD), gluteus medius (Gmed) and gluteus maximus (Gmax). The raw EMG data were full-wave rectified, low pass filtered (6 Hz), and integrated (IEMG) over the portion of each movement cycle that corresponded to the prime mover action of each muscle. The IEMG data were subsequently normalized to a percent of the data obtained at the greatest resistance level. Immediately following each bout

of 3 cycles at each resistance level, subjects provided a numerical rating of their perceived exertion, via the Borg category-ratio (CR-10) scale. Figure 2 illustrates a sample tracing the processed EMG data over a series of rotation cycles at one subject at a resistance level of 8.

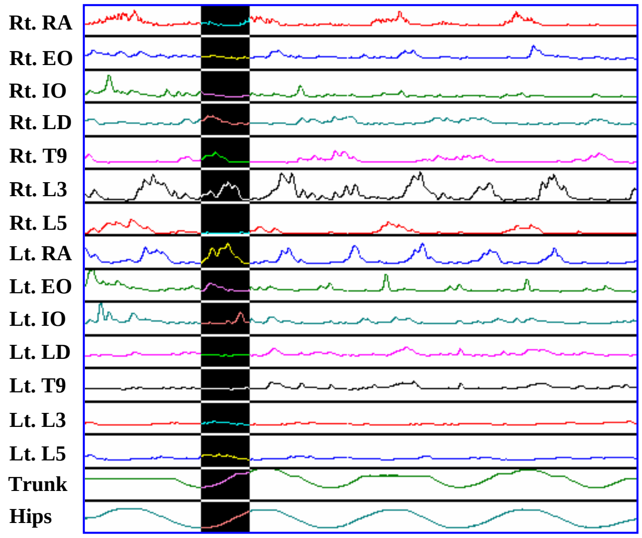

FIGURE 2: Sample tracing of processed surface EMG tracings from the trunk muscles during cyclic exercise on the trunk rotation device. The highlighted region indicates a rightward rotation.

RESULTS AND DISCUSSION

The results demonstrated a significant ($p<0.05$) increase in ratings of perceived exertion across the resistance levels (Figure 3).

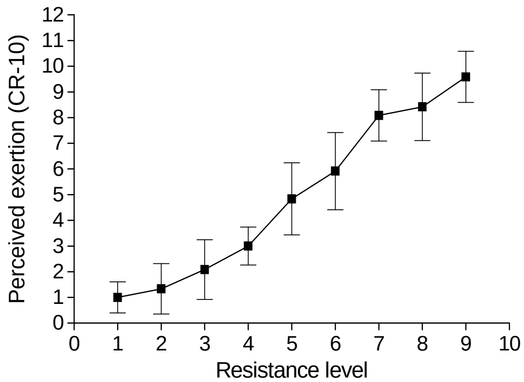

FIGURE 3: Ratings of perceived exertion, as a function of resistance level during trunk rotation exercise.

With respect to the normalized IEMG data, significant ($p<0.05$) increases were observed for most muscles beyond resistance level 4, when considering their primary motion, as a function of resistance level (Figure 4).

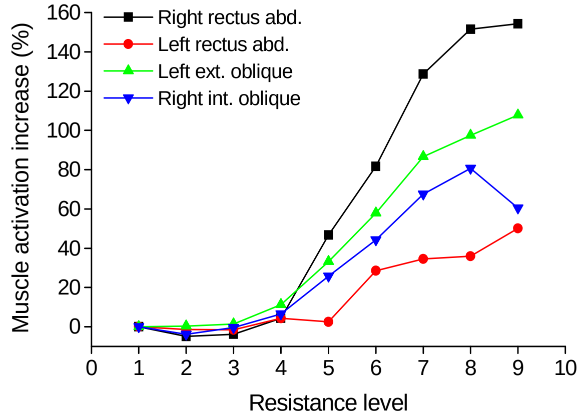

FIGURE 4: Normalized IEMG data of the abdominal muscles during rightward rotations, as a function of device resistance level.

CONCLUSIONS

The major findings of the present study demonstrate that the newly designed trunk rotation exercise device was effective at progressively recruiting the trunk rotator muscles that are active in the intended motions. As confirmed by the expected increase in perceived exertion, current investigations are addressing the efficacy of using such a device for sport-specific training and performance enhancement.

REFERENCES

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