HUMAN PERFORMANCE INNOVATION LAB

SCHOOL OF KINESIOLOGY | UNIVERSITY OF MICHIGAN

ACTIVMOTION BAR™

INTRODUCTION

Utilizing their expertise in human motion analysis, Drs. G. Goulet, J. Deneweth and S. McLean, and S. Kessler of the Human Performance Innovation Laboratory at the University of Michigan are conducting a study aimed at providing novel insights into muscle activation differences when using a variety of weighted exercise equipment.

METHODOLOGY

Participants & Instrumentation

Seventeen active men and women aged 30-50 were recruited to participate in a one-hour laboratory session. Participants were instrumented with electromyography (EMG) and inertial (IMU) sensors on the following muscles and segments (Figure 1):

EMG

1. Middle Deltoid
2. Latissimus Dorsi
3. Erector Spinae (thoracic and lumbar)
4. External Oblique
5. Pectoralis Major
6. Rectus Abdominus
7. Gluteus Medius
8. Vastus Medialis
9. Biceps Femoris

IMU

1. Upper thoracic
2. Lower thoracic
3. Pelvis
4. Bilateral upper arm
5. Bilateral forearm
6. Bilateral thigh
7. Right shank

EMG and IMU placement was not disturbed for the entirety of the data collection session. Additionally, participants wore a heart rate monitor to assess resting and continuous heart rate.

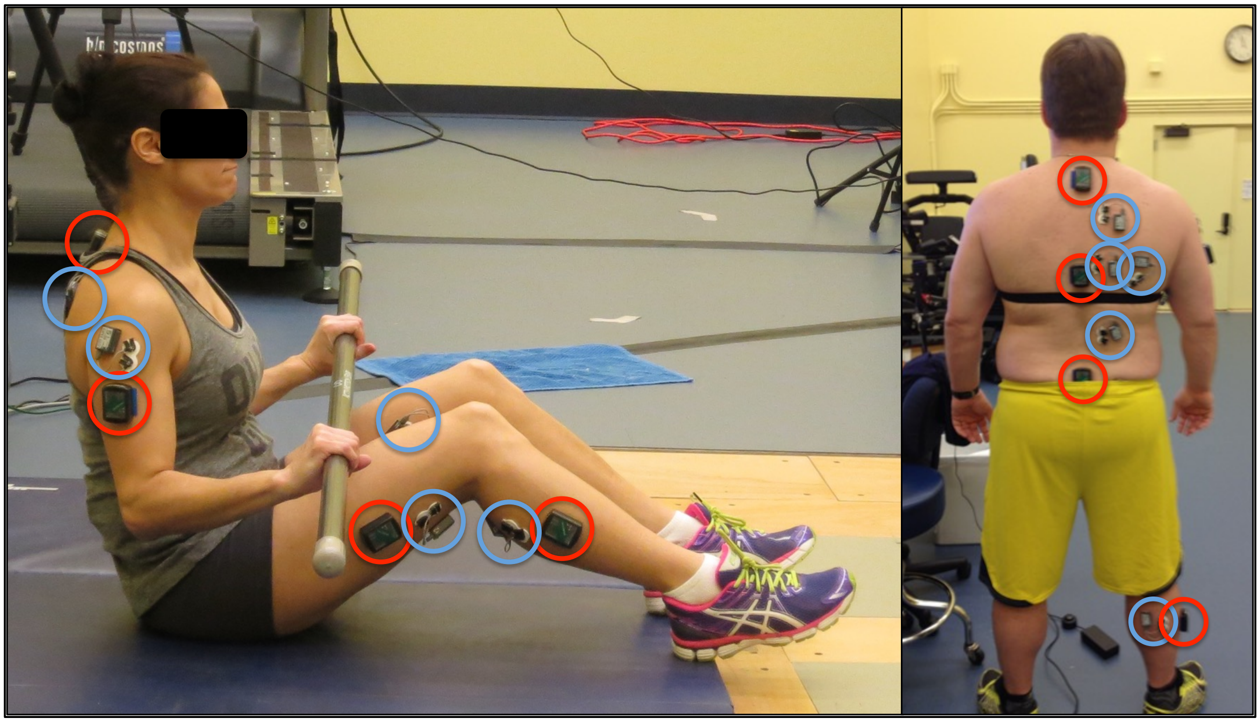

Figure 1. Participants instrumented with electromyography (blue) and inertial (red) sensors. Sensors were placed on bilateral arms and legs, and the back to monitor muscle activity and body segment kinematics.

Following a 5-minute treadmill warm-up, participants were familiarized with a series of exercises via video instruction. Exercises included:

1. Hinge, right-left swing
2. Overhead side-bend
3. Reverse lunge, balance, press
4. Sit-up, hold, rotate
5. Steering wheel squat

Exercises were performed with three apparatus: standard fitness bar (SB), medicine ball (MB), and ActivMotion bar (AMB). The weight of each apparatus was 10 lbs for males and 6 lbs for females. Participants practiced the exercises with the apparatus until they felt comfortable.

Synchronous EMG, IMU, and high-speed video data were collected at 1,500 Hz, 200 Hz, and 100 Hz, respectively, while participants followed the instructional video for each exercise (six repetitions per exercise). In addition to providing further instruction, the video served to control the pace of exercise execution. Throughout the exercises, consistency in range of motion across apparatus was ensured using real-time kinematics, derived from IMU output.

Participants performed all exercises with each apparatus, resulting in 15 combinations of movements (five exercises × three apparatus). The order of exercises was randomized, and the order of apparatus within each exercise was also randomized to eliminate fatigue and learning effects. Fatigue effects were additionally monitored and minimized by ensuring between-exercise heart rate was within 10% of resting heart rate.

Data Processing

EMG signals were calibrated by subtracting the mean of the raw signal from each data point. Signals were then full-wave rectified, low-pass (dual-pass, butterworth; cut-off: 500 Hz) and notch (59-61 Hz) filtered, and subsequently submitted to root mean squared (RMS) averaging with a window length of 300 ms (MR3 Software, Noraxon; Figure 2). High-speed reference video was used to crop exercises into individual repetitions for further analysis.

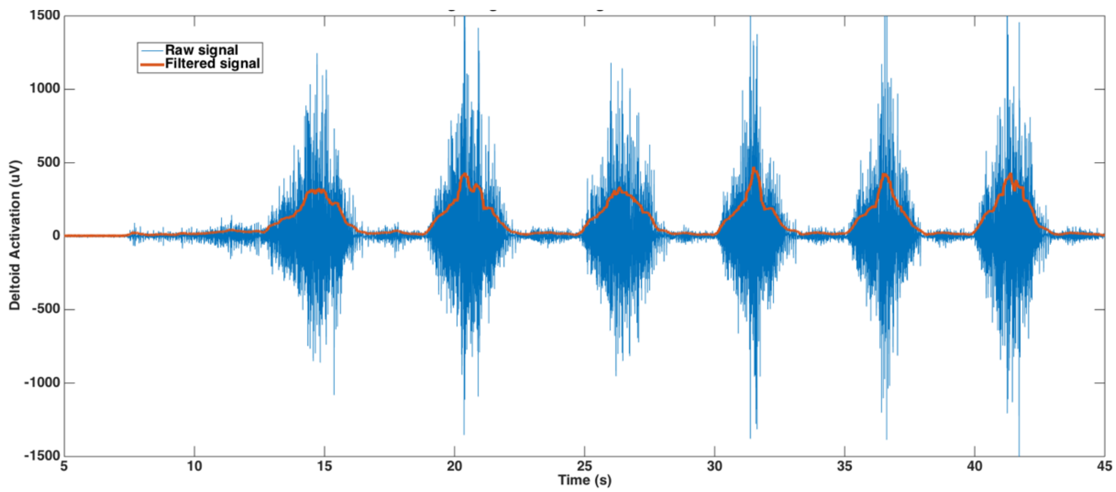

Figure 2. Exemplar electromyography signal from deltoid during six repetitions of the *hinge swing* exercise. Raw, unprocessed (blue) and processed (rectified, filtered, averaged; red overlay).

Analysis

Processed EMG signals were analyzed using a custom routine (Matlab) that extracted maximal amplitude (mV) and the area under the activation signal (mV-ms). Five satisfactory repetitions were included for analysis for each exercise and apparatus combination. Trials with significant movement artifact in the EMG signal, or trials that were incorrectly performed were omitted from analysis. Amplitude and activation (i.e., area under the curve) for all 15 movement conditions were submitted to a repeated measures analysis of variance to determine the within-subject effect of exercise apparatus on muscle activation (SPSS 20).

Results

For the participants analyzed to-date (n = 9; mean age: 39.4 ± 5.0 yrs), ActivMotion bar resulted in greater muscle activation in seven of the nine muscles analyzed, relative to the standard bar and the medicine ball (Figure 3; activation for the gluteus medius and biceps femoris was consistent across apparatus). Significant differences were found in the deltoid, latissimus dorsi, oblique, pectoralis major, rectus abdominus, trapezius, and vastus medialis muscles ($p<0.05$; Table 1). Additionally, ActivMotion bar tended to result in greater activation in the erector spinae muscles, relative to the standard bar and the medicine ball ($p<0.10$; Table 1 and Figure 3).

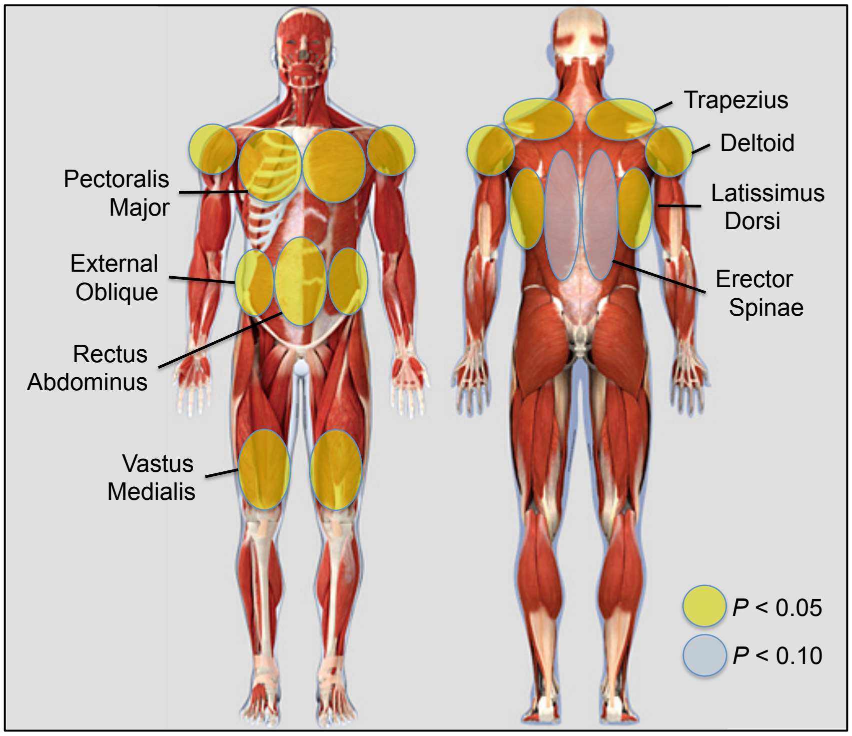

Figure 3. Schematic of muscles with increased activation when using the ActivMotion bar, compared to a standard fitness bar or medicine ball.

Table 1. Statistically significant (p<0.05) percent increase in muscle activation (active time × amplitude) with ActivMotion bar, relative to standard fitness bar or medicine ball. p<0.10 where noted *.

Muscle	Standard Bar %	Medicine Ball %
Deltoid	28	93
Latissimus Dorsi	15	—
Pectoralis Major	15	28
External Oblique	18	22
Rectus Abdominus	—	13
Middle Trapezius	22	77
Vastus Medialis	12	27
Erector Spinae	21*	—

Conclusion

When controlled for range of motion, static weight, and speed of movement, the ActivMotion bar elicited greater muscle activation, relative to a standard fitness bar or medicine ball. Ostensibly, the increase in muscle activation was the result of the internal passive weights, which generated a dynamic moment of inertia, thereby enhancing the stabilizing demands on the muscles.