OCTANE FITNESS: WHITE PAPER

SUBJECT:

Muscle recruitment and joint loading analysis: LateralX

A study by graduate students at Saint Cloud State University Human Performance Lab, St. Cloud, Minnesota

The LateralX elliptical trainer introduces a unique lateral elliptical motion that moves a user's stride through three planes of motion. The LateralX uses electronic motors to allow users to change the width of their lateral motion during their workout. Users can perceive a significant change in their workload and muscles engaged when at the narrowest and widest lateral width settings. **This analysis explores the differences in muscle recruitment and joint loading at these two different lateral width settings and comments on the loads and joint angles using the LateralX versus typical elliptical cross-trainers as well as the natural motions of walking, jogging and running.** This paper presents the results of this scientific analysis as well as outlining a practical application in a rehab facility.

Study Thesis

The purpose of this study was to determine how torques at the ankle, knee and hip differ at two different width settings on the LateralX—namely the least amount of lateral width (ST for "standard", lateral width "1") and the widest amount of lateral width (LAT, lateral width "10"). In addition, an electromyography (EMG) was used to determine muscle activation at each width. The results of the torque and EMG analysis at the different joints and settings provide data that indicates which muscle groups are active through the full range of movement on this machine.

Research

Subjects were filmed by two cameras that were calibrated and synced to create a 3D coordinate system using Simi Motion Software while performing two trials on the Octane Fitness LateralX, with rest between the trials. The two trial settings tested were maximized lateral movement (LAT) and standard movement (ST). During the first trial, the subjects were instructed to self-select a resistance level and pedal RPM that provided a workload of 11 ("neither light nor heavy") on the Borg RPE scale; these same settings were used for the second trial. Data was collected for five seconds at the end of each five-minute trial. Reflective markers were placed at the joints of the right leg on both the posterior and lateral surfaces to provide data for the 3D location of each joint center.

Bertec force plates were also anchored to the pedal of the machine and reflective markers were also placed on the right foot to track its position throughout the trials. Component force vectors from the plate were transformed into respective components that coincided with the 3D filming axis. This allowed the calculation of the center of pressure (COP) under the foot in the filming coordinate system.

The electromyography (EMG) was used to determine muscle activation and placed on the subject's hip adductors (ADD), the quadriceps (QUAD) and the hip abductors (ABD). Standard EMG skin preparation was followed including exfoliation and removal of excess hair as necessary.

Results

All torques reported in this document are the torques produced by the muscles and/or ligaments. For example, throughout the stance phase, the quadriceps produce a knee extensor torque. This is the knee torque that we would report, not the knee flexor torque produced by the external force beneath the foot.

Ankle Torques — The average torques produced about the medial-lateral (ML) axis of the ankle indicated that plantar flexors were active during both the ST (33.7N•m) and LAT (40.8N•m) trials. The paired T-test showed no statistically significant difference between the two conditions.

Knee Torques — Average torque data indicated that knee extensors were active during both the ST (24.8N•m) and LAT (16.6N•m) trials. The paired T-test revealed no statistically significant difference between the two conditions. The average torques produced about the anterior-posterior (AP) axis of the knee indicated that the knee joint produced a varus torque (10.9N•m) during the ST trials and a valgus torque (20.4N•m) during the LAT trials. The paired T-test showed that this difference was statistically significant.

Hip Torques

Average torque data indicated that hip extensors were active during both the ST (27.6N•m) and LAT (30.0N•m) trials. The paired T-test showed no significant difference between the two conditions (p=0.75). The average torques produced about the AP axis of the hip indicated that hip adductors were active (0.8N•m) during the ST trials compared to the hip abductors (20.4N•m) during the LAT trials. However, the paired T-test revealed that this difference was not significant.

The results showed that the "extensors" at the ankle, knee and hip worked simultaneously to support the subject. Visualized from the side, this can be appreciated by recognizing that the upward vertical ground reaction force beneath the foot tends to flex the ankle (dorsiflex), knee and hip. To counter this, the extensors of the ankle (plantar flexors), knee and hip were recruited. This explains why there was no difference between the measured ST and LAT joint torques, and why there was no difference in the QUAD EMG.

The ground reaction force was directed on opposite sides of the knee for the ST and LAT techniques. With ST, it passed laterally and with LAT it passed medially. So, the medial knee ligament (medial collateral) would be expected to undergo tension with ST, while the lateral knee ligament (lateral collateral) would be expected to undergo tension with LAT.

When examining the individual torque curves about the anterior-posterior axes (front view), we observed that the subjects exhibited a more consistent strategy with the LAT technique. The LAT technique seemed to force all subjects into a fairly consistent biphasic knee and hip loading. There was much more variability in the torque curves with the ST technique.

Both the standard and maximized lateral elliptical patterns produced similar leg torques and muscle activity. The only significant difference was the tendency of the ST to place the medial collateral knee ligament under tension while the LAT placed the lateral collateral knee ligament under tension. We do not believe this difference has any meaningful significance.

Research Summary

The study found that both the standard and maximized lateral width elliptical patterns produced similar leg torques and muscle activity. The only significant difference was the tendency of the ST to place the medial collateral knee ligament under tension while the LAT placed the lateral collateral knee ligament under tension. This emphasis was not deemed significant.

The peak knee torques found are similar to the torques reported for walking and jogging. **This comparison indicates that the lateral motion of the LateralX is no more stressful on the medial and lateral ligaments of the knee than walking and running.**

Practical Application

Over the course of the study, an additional LateralX unit was placed at OSR Physical Therapy in Eden Prairie. Therapists at OSR found the biomechanics of the LateralX favorable in treating patients recovering from hip, knee, ankle and lower back surgeries. Nate Stier, MPT, ATR, defined several key aspects of the LateralX workout that make it a good platform for use with patients rehabilitating from lower body extremity surgeries:

1. Increased quadriceps and gluteal strengthening vs. standard elliptical machine
2. Ability to adjust the amount of lateral motion
3. Increased lateral gluteal activation with maximized lateral motion vs. standard elliptical machine
4. Well-designed ergonomic set up of the pedals and converging handles
5. **Increased stability / proprioception aspect of rehab with multi-planar motion**
6. **Well designed biomechanic motion which protects against end-range extension of the hip joint**
7. Well-suited for upper body scapular / shoulder stabilization exercises

OSR prescribes the use of the LateralX machine for use in rehab for patients that are recovering from a large range of conditions including:

- Hip surgeries (labral repairs, femoral acetabular impingement, etc.)
- Knee arthritis / post-surgery
- Ankle conditions
- LBP / LB arthritis / disc herniations
- Overweight / diabetic conditions
- Shoulder / scapular / elbow Issues

OSR therapists found the LateralX to be a favored platform for their patients as it provides a variety of strengthening benefits on one machine.

Summary
Users of the LateralX perceive a significant change in their workload and muscles engaged when at the narrowest and widest lateral width settings. This study found that both the standard and maximized lateral width elliptical patterns produced similar leg torques and muscle activity with some significant difference in the tensions placed on the medial collateral knee ligament and the lateral collateral knee ligament. **These tensions, while different from each other at the two widths, are similar to and no more stressful on the knees than the torques reported for walking and jogging.**

The LateralX compares favorably with standard elliptical modality for rehabilitation of a wide range of conditions. Key benefits include increased quadriceps and gluteal strengthening, the ability to adjust the amount of lateral motion and increased lateral gluteal activation with maximized lateral motion. Further, the LateralX may be favored by patients since it offers a variety of strengthening benefits in one machine.

REFERENCES

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Similarity of joint kinematics and muscle demands between elliptical training and walking: implications for practice. Burnfield JM, Shu Y, Buster T, Taylor A. Institute for Rehabilitation Science and Engineering, Director, Movement and Neurosciences Center, Institute for Rehabilitation Science and Engineering, Madonna Rehabilitation Hospital, Lincoln, NE.

Study: "Kinematic analysis of Octane Fitness' LateralX", study by graduate students of St Cloud State's Human Performance Lab, December 2011, under the direction of Glenn Street, PhD, Exercise and Sports Science: Biomechanics.

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For more information, contact Octane Fitness at *www.octanefitness.com* or *888-OCTANE-4*.

About Nate Stier

Nate Stier, MPT, ATR, is the co-founder of Orthopedic and Sport Rehabilitation in Chanhassen and Eden Prairie, Minnesota. Mr. Stier is the former Director of Rehabilitation and Assistant Athletic Trainer for the National Football League's Minnesota Vikings.