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An electromyographic analysis of selected asana in experienced yogic practitioners

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ABSTRACT

The purpose of this study was to assess electromyographic (EMG) output of the anterior tibialis (TA), medial head of the gastrocnemius (GA), rectus femoris (RF), bicep femoris (BF), and gluteus medius (GM) in experienced yogic practitioners during selected yoga asana. A secondary purpose was to examine the differences in EMG output in unilateral V. bilateral standing yoga asana. The study was a single occasion descriptive design. Thirteen healthy yoga practitioners (1 male, 12 females, average age of 37.5) with more than five years of experience were recruited. EMG activity was recorded during maximum voluntary isometric contractions (MVIC) of the TA, GA, RF, and BF using the Biodex Multijoint System®, and GM using manual muscle testing position. Subjects then performed the following yoga asana while EMG activity was recorded: downward facing dog, half-moon, tree, chair, and warrior three pose. Each asana was held for fifteen seconds and performed three times. EMG data were band pass filtered and the root mean square was obtained. Asana data were then amplitude normalized with the subjects' MVIC data. Integrated EMG was calculated for TA, GA, RF, BF and GM, in each asana. A multilevel regression analysis was performed, and peak EMG data was compared. Analysis between muscles showed that during CH and DD EMG activity was greatest in the TA muscle compared to the other muscles, while during HM and WR the GA muscle showed the greatest activity. Analysis within muscles showed low GA, BF, and GM activity during chair pose and downward facing dog compared to half moon, tree, and warrior three, and high RF activity during chair compared to the other poses. In conclusion, there were differences in frontal and sagittal plane muscle activation between single limb and double limb poses in experienced yogic practitioners.

1. Introduction

Yoga is alternative form of exercise that improves health and fitness through the integration of the mind, body, and spirit. Yoga is gaining popularity as a form of exercise in the United States and other countries (Tindle et al., 2005). Hatha yoga incorporates asana (postures), pranayama (breathing techniques) and meditation (Iyengar, 2001). Hatha yoga can improve an individual's health, well-being, flexibility and strength. Chandler (2001) noted yoga improved: circulation, respiration, cardiac function, and balanced mental functioning. Researchers have shown that yoga reduces low back pain (Galantino et al., 2004; Williams et al., 2005; Tilbrook et al., 2011), reduces blood pressure (Shantakumari et al., 2012), improves peak hip extension range of motion (DiBenedetto et al., 2005) and increases gait speed in community dwelling older adults (Zettergren et al., 2011). Although studies exist that have evaluated the effects of yoga in a variety of areas (Chandler, 2001; Galantino et al., 2004; Williams et al., 2005; Tilbrook et al., 2011; Shantakumari et al., 2012; Zettergren et al., 2011), a paucity of literature exists examining EMG output during yoga asana.

Muscle activation and lower extremity (LE) strength are crucial for gait, balance, functional mobility, and prevention of LE injury (Wolfson et al., 1995; Carville et al., 2007; Distefano et al., 2009). Distal deformities such as patellofemoral pain (Baldon et al., 2014;

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Magalhães et al., 2010), anterior cruciate ligament injury (Lauridsen et al., 2014; Hewett et al., 2006), tibial stress fracture (Milner et al., 2010), and iliotibial band friction syndrome (Ferber et al., 2010) may be secondary to proximal muscle weakness (Boren et al., 2011). Rectus Femoris strength is crucial for the sit to stand transition (Whipple et al., 1987) and RF weakness may contribute to falls in older adults (Whipple et al., 1987; Carville et al., 2007). Biceps Femoris strength is crucial for initiating hip extension and limiting hip flexion on the stance and swing limbs during gait (Jonkers et al., 2003). Weakness or injuries may lead to abnormalities in gait such as poor ankle motion, and diminished initiation of hip extension on the stance limb, with increase in hip flexion on the swing limb (Jonkers et al., 2003). Weakness in the tibialis anterior and gastrocnemius have been associated with both an increase risk of falling and a decreased ability to perform sit to stand in older adults (Carville et al., Whipple et al., 1987; Barnett et al., 2003). Finally, Jonkers et al. (2003, pg. 264) suggested: "Maintenance of stance limb stability requires interplay of glut max, BF, GA and Soleus." In addition to general function, some researchers have examined the difference in muscle activation in unilateral versus bilateral activities.

Krause et al. (2004) studied gluteus medius muscle activity in five standing exercises. The results revealed that gluteus medius muscle activity was statistically greater in single limb stance exercises when compared to double limb stance exercises. Altering the position of the lower extremity and/or the distal load also affects GM muscle activity. Earl (2004) examined 20 healthy subjects while they performed three single leg stance exercises. A significantly greater amount of muscle activity was noted when the tested limb was placed in abduction with internal rotation. Distefano et al. (2009) examined 21 healthy, active subjects who completed 12 exercises to target the gluteus medius and maximus. The EMG results showed exercises that best activated the gluteus medius and gluteus maximus were side-lying abduction, single limb squat, and single limb deadlift.

Research exists investigating various rehabilitative exercises using surface EMG (Distefano et al., 2009; Lauridsen et al., 2014; Cordova et al., 1999). In addition, researchers have used specific protocols to examine EMG output in unilateral versus bilateral standing activities (Distefano et al., 2009; Earl, 2004; Krause et al., 2004). However, a paucity of research exists using surface EMG to investigate yoga asana. Therefore, the purpose of this study was to assess electromyographic output of the anterior tibialis, medial head of the gastrocnemius, rectus femoris, bicep femoris, and gluteus medius in experienced yogic practitioners during selected yoga asana. A secondary purpose of this study was to examine the difference in EMG output in bilateral versus unilateral standing yoga asana.

2. Methods

2.1. Subjects

The Human Experimentation Committee/Subject Review Board (HEC/SRB) at Quinnipiac University granted approval of the experiment. Thirteen healthy subjects, 1 male and 12 females with an average of 37.5 years were recruited (see Table 1). Potential participants were recruited via email. All subjects were required to have at least five years of yoga practice at a minimum of two times per week. Subjects were excluded if they had any chronic or known injuries from yoga. Prior to completing the study, participants were given a brief overview of the study and were educated on the potential risks and benefits of the study and signed an informed consent.

Table 1
Demographics, 13 subjects (12 females and 1 male).

	Mean $\bar{x}$	SD	Range
Age in Years	37.5	±5.59	19–59
BMI in kg/m	22.48	±1.56	18.9–24.8
Years of Yoga Experience	9.27	±4.63	5–20

2.2. Materials

The surface electrodes used for EMG collection were MA300 (Motion Lab Systems, Baton Rouge, LA). EMG data was collected via a single-ended amplifier with common mode rejection ration (CCMR) of 130 db. Subjects wore a battery operated 16-channel transmitter that transferred the EMG signal to a receiver where the data was further amplified (1 time for a total gain of 1000 times). Motion Monitor (Innsport, Chicago, IL) software was used to obtain the EMG signal. MVICs of the TA, GA, RF and BF were collected using the Biodex Multijoint System (Biodex, 2006) following the protocol provided by its corresponding operation manual. MVIC of the GM was collecting using manual muscle testing Reese and Conway, 2005). Subjects were provided with a standard 68″ X 24″ X1/8″ yoga mat to perform asana and a standard yoga block to modify asana if needed.

2.3. Procedures

Each subject participated in a two-hour single data collection session in the Motion Analysis Lab at Quinnipiac University. The dominant leg was used for all tests and measures. The subjects' dominant leg was determined through the use of a stepping strategy test. The skin was scrubbed with 70% isopropyl alcohol until erythema was present and shaved if needed. Disposable electrodes were placed over the belly of the TA, GA, RF, BF, and GM. The SENIAM (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles) protocol was used for electrode placement (http://seniam.org/). One ground electrode was placed inferior and medial to the tibial tuberosity on the dominant leg. Correct EMG placement was determined through the use of a neurostimulater and manual muscle testing. Electrodes were secured in place by pre-wrap, medical tape, and clear tape. Leads were attached to a battery operated 16-channel transmitter.

To collect MVIC data, the examiner provided verbal encouragement. Subjects were instructed to contract each muscle with a ramp up of 2 s, hold maximally for 6 s, and ramp down of 2 s. EMG amplitude signal was simultaneously recorded.

After MVIC data were collected, subjects were given a 60 s break to prevent muscle fatigue. Subjects then performed the following yoga postures: adho mukha svanasana (downward facing dog), ardha chandrasana (half moon pose), vrksasana (tree pose), utkatasana (chair pose), and virabhadrasana III (warrior three). Each pose was explained to the subjects and specific verbal instruction was given based on standard language (Lasater, 2003). Subjects were allowed to practice each pose prior to collection. For each pose, EMG data was recorded for 3, 15-s trials, with up to a 60 s rest between poses. Asymmetrical poses (half moon pose, tree pose, warrior three pose) were recorded with dominant leg as stance leg.

2.4. Data analysis

Raw EMG data was band pass filtered using a 4th order Butterworth filter with cutoff frequencies of 10 and 350 Hz. The root mean square (RMS) of the filtered signal was then obtained using a window of 250 ms. The peak RMS value of each MVIC trial was then determined. For each asana trial, the EMG amplitude of each

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