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Muscle utilization patterns vary by skill levels of the practitioners across specific yoga poses (asanas)

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KEYWORDS
Electromyography;
Yoga pose;
Asana

Summary
Objective: To compare muscle activation patterns in 14 dominant side muscles during different yoga poses across three skill levels.
Design: Mixed repeated-measures descriptive study.
Setting: University neuromuscular research laboratory, Miami, US.
Participants: A group of 36 yoga practitioners (9 M/27 F; mean ± SD, 31.6 ± 12.6 years) with at least 3 months yoga practice experience.
Interventions: Each of the 11 surya namaskar poses A and B was performed separately for 15 s and the surface electromyography for 14 muscles were recorded.
Main outcome measures: Normalized root mean square of the electromyographic signal (Nrm-sEMG) for 14 muscles (5 upper body, 4 trunk, 5 lower body).
Results: There were significant main effects of pose for all fourteen muscles except middle trapezius ($p < .02$) and of skill level for the vastus medialis; $p = .027$). A significant skill level × pose interaction existed for five muscles (pectoralis major sternal head, anterior deltoid, medial deltoid, upper rectus abdominis and gastrocnemius lateralis; $p < .05$). Post hoc analyses using Bonferroni comparisons indicated that different poses activated specific muscle groups; however, this varied by skill level.
Conclusion: Our results indicate that different poses can produce specific muscle activation patterns which may vary due to practitioners' skill levels. This information can be used in designing rehabilitation and training programs and for cuing during yoga training.

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List of abbreviations

EMG electromyography

MVC	maximal voluntary contractions
NrmsEMG	normalized root mean square EMG

Muscles

PECS	pectoralis major sternal head
$Delt_{ANT}$	anterior deltoid
$Delt_{MED}$	medial deltoid
BB	biceps brachii
Tri	triceps brachii
$TRAP_{UP}$	upper trapezius
$TRAP_{MID}$	middle trapezius
RAM	rectus abdominis
ES	erector spinae
RF	rectus femoris
VM	vastus medialis
BF	biceps femoris
$Gastroc_{LAT}$	gastrocnemius lateralis
TA	tibialis anterior

Poses

Chr	chair (Utkaasana)
Dog_{DWN}	downward facing dog (Adho Mukha Svanasana)
Dog_{UP}	upward facing dog (Urdhva Mukha Svanasana)
FFold	forward fold (Uttanasana)
HLift	halfway lift (Urdhva Mukha Uttanasana)
Mnt_{DWN}	mountain pose with arms down (Tadasana)
Mnt_{UP}	mountain pose with arms up (Urdhva Hastasana)
$Plnk_{HI}$	high plank (Dandasana)
$Plnk_{LOW}$	low plank (Chaturanga Dandasana)
War_{NO-DOM}	non-dominant side warrior 1 pose (Virabhadrasana I)
War_{DOM}	dominant side warrior 1 pose

Skill levels

ADV	advanced group
INST	instructor group
NOV	novice group

Introduction

Yoga, originated in ancient India, integrates physical, mental, emotional, and spiritual dimensions to improve the holistic health. The benefits of yoga include: increased muscle strength and endurance,[1–6] muscle power,[7] anaerobic power,[8] flexibility,[1,3,5] balance and coordination,[1,4] and pain attenuation.[9,10] However, yoga is not without its detractors. Critics have argued that several poses may go beyond some practitioners' capabilities and produce negative consequences, such as muscle strains and ligament rupture.[11]

Yoga postures comprise basic elements such as standing, sitting, forward and backbends, twists, inversions and lying. Each pose is expected to activate specific muscles. To our knowledge, only one study[12] has examined muscle utilization patterns during specific yoga poses and no studies have quantified variations in muscle activity as practitioners' skill levels evolve with practice. As yoga becomes more popular around the globe, understanding these factors may reduce injuries, provide guidelines for improved progression and cuing, and allow the design of pose sequences which can target needs related to specific sports, special populations and rehabilitation programs.

The purpose of this study was to quantify differences in muscle activity during different yoga poses by novices (NOV), advanced practitioners (ADV) and instructors (INST). Results can help yoga instructors choose appropriate postures based on students' skill and fitness levels, allow practitioners to modify their practice to match their needs and capacities, and provide critical data for prevention and rehabilitation programs designed to treat the needs of athletes, the general community, and special populations.

Methods

Participants

Thirty-six Baptiste yoga practitioners using Vinyasa style participated in the study (9 men, 27 women; mean age $\pm$ SD, 31.6 $\pm$ 12.6 years). Subjects were recruited through flyers and personal contacts at yoga studios and wellness centers. To be included in the study an individual must fall into one of three categories: NOV having practiced for 3–12 months; ADV who had practiced more than 3 years; or INST who possessed a yoga instructor certification. Additionally, subjects must have participated in yoga training for 1–1.5 h at least once per week for at least three months, must not have participated regularly in any other exercise program, and must have been capable of completing the study's yoga sequence without assistance. Individuals with musculoskeletal and neurological impairments or unresolved injuries were excluded from study participation. Participants were informed of experimental procedures and completed a written consent approved by the University's Subcommittee for the Use and Protection of Human Subjects. Participants' characteristics are presented in Table 1. A power analysis using an effect size of 0.25, α of 5% and power of 95%, yielded a minimal sample size of 27.

Procedures

Participants arrived at the laboratory and completed the consent form and health questionnaire. They then warmed-up using surya namaskar (sun salutation) A three times and surya namaskar B twice at a self-determined pace. Next, electrodes were placed on the skin over the muscles of interest on participants' dominant side (32 right-handed/4 left-handed). Fourteen muscles were randomly evaluated on two separate days. Surface electromyography (EMG) data were normalized across subjects and collection days, using EMG results from 3 s maximal voluntary contractions (MVC) targeting each muscle. Following preparation and normalization, each subject performed 11 Sun salutation poses (Fig. 1) maintaining each for 15 s. The pose sequences were randomized for each subject using a random number generator (Microsoft Excel, 2010; Microsoft Corp. Redmond, WA). Each pose was digitally recorded and evaluated by an independent group of yoga instructors blinded to the subjects' skill level assignments, to confirm each subject's skill level classification. Subjects were asked to avoid doing intensive