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Muscle-specific responses to traditional yoga asanas: A surface EMG-based investigation

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Abstract

Background: Yoga asanas are increasingly being integrated into rehabilitation and physical training programs for their potential benefits on muscle function and flexibility. However, limited evidence exists regarding their specific impact on lower limb muscle activation.

Objective: The present study aimed to evaluate the effects of three yoga asanas—Poornna Titali Asana, Utthita Trikonasana, and Padanguli Shakti Vikasaka—on the electromyographic (EMG) activity of four key lower limb muscles: Adductor Longus, Gracilis, Gastrocnemius, and Soleus.

Methods: A within-subject design was used with fifteen participants (n = 15). Surface EMG was recorded pre- and post-intervention for each asana. Paired t-tests were conducted to assess changes in mean muscle activation. Significance was set at $p < 0.05$.

Results: Statistically significant reductions in muscle activation were observed in the Gracilis muscle during Utthita Trikonasana ($p = 0.014$), and in the Gastrocnemius muscle during Padanguli Shakti Vikasaka ($p = 0.004$). No significant changes were noted in Adductor Longus or Soleus across any asana.

Conclusion: The findings suggest that certain yoga asanas can selectively influence lower limb muscle activity. Utthita Trikonasana may reduce medial thigh (Gracilis) load, while Padanguli Shakti Vikasaka appears effective in reducing activity in the Gastrocnemius. These insights support the use of targeted yoga postures in therapeutic and conditioning contexts. Further research with larger sample sizes and normalized EMG data is recommended.

Keywords: Electromyography (EMG), Yoga Asanas, Muscle Activation, Adductor Longus, Gracilis, Gastrocnemius, Soleus, Poornna Titali Asana

Introduction

Yoga is a mind-body exercise developed in India, which has gained popularity worldwide (Deshi & Das, 2023; Deshi & Pujari, 2023; Samariya & Sarma, 2024; Saud *et al*., 2022; Whissell *et al*., 2021) [1-2, 5, 6, 10]. It consists of a set of physical poses and deep breathing that is known to increase flexibility and muscle strength and also improve the respiratory system. The body movements of yoga practitioner must be smooth such that they can attain the required postures and in turn, activate the muscles influenced by the asana. Muscle activation patterns can yield information about the kinematics of the body during Yoga asanas (Suma *et al*., 2022) [8]. Yoga postures comprise basic elements such as standing, sitting, forward and backbends, twists, inversions and lying. Each pose is expected to activate specific muscles (Ni *et al*., 2014) [3]. The current report describes the lower-extremity physical demands (as measured by the JMOFs and electromyography [EMG]) associated with the performance of 7 standing yoga asanas that are commonly taught in senior yoga classes (Wang *et al*., 2013) [9]. Electromyography (EMG) is unique in specifying muscle activation. Specifically, surface EMG is a convenient index of muscle excitation and allows a description of muscular patterns (Salem *et al*., 2013; Sousa & Tavares, 2012) [4, 7].

The lower limb muscles play a crucial role in maintaining postural stability, balance, locomotion, and overall functional performance. Strengthening these muscles, particularly the adductor longus, gracilise, gastrocnemius, and soleus, is essential for athletes, physically active individuals, and rehabilitation populations alike. Weakness or imbalance in these muscle groups can lead to reduced performance efficiency, impaired gait mechanics, and increased risk of injury.

Yogic training, rooted in traditional Indian physical culture, has emerged as a holistic approach to improve strength, flexibility, neuromuscular control, and body awareness. Unlike conventional resistance training, yoga combines isometric contractions, breath control, and static-dynamic postures that can effectively engage and activate multiple muscle groups simultaneously. Recent studies have shown that yoga can significantly enhance muscular strength, proprioception, and joint stability, particularly in the lower limbs.

Despite the growing popularity of yoga in fitness and rehabilitation settings, limited research has been conducted to objectively assess its impact on lower leg muscle activity using surface electromyography (EMG). Evaluating EMG activity allows for precise quantification of muscle activation patterns, providing insight into the neuromuscular adaptations induced by yoga practice.

This study aims to investigate the effect of a 6-week yogic training intervention on the EMG activity of selected lower leg muscles—namely, the adductor longus, gracilise, gastrocnemius, and soleus—in healthy young males. By comparing pre- and post-training muscle activation levels between an experimental group (receiving yoga training) and a control group (no intervention), this study seeks to determine whether yoga can serve as an effective method for enhancing lower leg muscular strength and activation.

Methods

Participants

A total of 15 male participants were recruited from the student population at the Lakshmibai National Institute of Physical Education (LNIPE), Gwalior. Participants were randomly assigned. Underwent a structured 6-week yogic training program focused on lower leg muscle activation and strengthening. Inclusion criteria for participation included: Age between 18–25 years, physically active and free from any lower limb musculoskeletal injuries, Not currently participating in any structured strength training program. Exclusion criteria included: History of orthopaedic or neurological disorders, Participation in other lower limb training programs during the study period, Inability to adhere to the intervention protocol. All participants were informed about the objectives and procedures of the study, and written informed consent was obtained prior to data collection.

Equipment

Electromyographic (EMG) activity of selected lower leg muscles was recorded using the BTS FREEEMG system (Bioengineering, 2011). This wireless surface EMG system offers high accuracy and mobility, allowing for real-time data collection during yoga postures. Electrode placement followed SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) guidelines to ensure consistency and reliability.

Intervention Protocol

The experimental group underwent a 6-week yogic training program focused on strengthening the lower leg muscles. Sessions were conducted 5 days per week, each lasting approximately 45 minutes. The yoga protocol included the following three asanas:

Poorn Titali Asana (Full Butterfly Pose) – To activate the hip and thigh region and improve flexibility in the lower limbs.

Utthita Trikonasana (Extended Triangle Pose) – Aimed at enhancing static balance, ankle stability, and lower leg engagement.

Padanguli Shakti Vikasaka (Toe Strengthening Exercise) – Focused specifically on intrinsic foot muscles and toe flexors/extensors.

Participants in the control group did not receive any intervention and were instructed to continue their usual physical activities without any additional training.

Procedure of data collection

The data collection was conducted in the Biomechanics Laboratory at LNIPE, Gwalior, following a standardized protocol to examine the effect of yogic training on the activation and strengthening of lower limb muscles.

Participant Preparation and Orientation

All participants were first briefed about the study procedures and provided with instructions regarding the EMG testing process. A familiarization session was conducted to introduce the yoga poses and ensure proper execution during EMG recording.

Muscle Selection

The following four muscles were selected for electromyographic analysis due to their critical role in lower limb stability and movement:

- Adductor Longus
- Gracilis
- Gastrocnemius
- Soleus

Electrode Placement and Setup

Surface electrodes from the BTS FREEEMG system (Bioengineering, 2011) were placed over each target muscle according to SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) guidelines. The skin was cleaned with alcohol wipes to reduce impedance before electrode placement.

Pre-Test (Baseline) Data Collection

EMG activity was recorded before the 6-week intervention for both the experimental and control groups.

Participants performed the selected yoga poses (Poorn Titali Asana, Utthita Trikonasana, and Padanguli Shakti Vikasaka) while EMG signals were recorded for the four target muscles.

Each posture was held for a standardized duration to ensure consistency across participants.

Intervention Period

The experimental group underwent 6 weeks of yogic training, 5 sessions per week, focusing on the three selected asanas targeting lower limb engagement.

The control group did not perform any yoga training and continued with their usual physical activity routines.

Post-Test Data Collection

After the 6-week intervention, EMG data were collected again using the same protocol and electrode positions to maintain consistency.

The same yoga postures were performed during post-test recordings.

Data Processing and Analysis:
EMG signals were processed using BTS software to extract Root Mean Square (RMS) values, reflecting muscle activation levels.
Paired t-tests were applied to compare pre- and post-test values within each group, to evaluate the effect of the yogic intervention on muscle activation and strength. All assessments were conducted under expert supervision to ensure protocol adherence, accurate data capture, and participant safety.

Statistical analysis
The data obtained from pre- and post-intervention EMG recordings were analysed using paired t-tests to determine the statistical significance of within-group changes. A significance level of $p < 0.05$ was set for all analyses.

Result

Table 1: Paired Sample t-Test Results for Muscle Activity Changes Across Selected Yoga Asanas

Muscle	Asana	Mean Difference	Std. Deviation	Std. Error Mean	t	df	p-value
Adductor Longus	Poornna Titali Asana	-2.56197	74.68312	19.28310	-0.133	14	0.896
	Utthita Trikonasana	2.65441	16.47060	4.25269	0.624	14	0.543
	Padanguli Shakti Vikasaka	-62.58405	199.90309	51.61476	-1.213	14	0.245
Gracilis	Poornna Titali Asana	-4.56909	32.38356	8.36140	-0.546	14	0.593
	Utthita Trikonasana	-14.59539	20.14986	5.20267	-2.805	14	0.014
	Padanguli Shakti Vikasaka	2.53122	37.75274	9.74772	0.260	14	0.799
Gastrocnemius	Poornna Titali Asana	-12.67045	47.41296	12.24197	-1.035	14	0.318
	Utthita Trikonasana	15.05061	39.45856	10.18816	1.477	14	0.162
	Padanguli Shakti Vikasaka	-18.47496	20.54642	5.30506	-3.483	14	0.004
Soleus	Poornna Titali Asana	10.54568	35.63666	9.20135	1.146	14	0.271
	Utthita Trikonasana	-11.41106	34.41971	8.88713	-1.284	14	0.220
	Padanguli Shakti Vikasaka	-0.95563	12.53012	3.23526	-0.295	14	0.772

Discussion of the Results
The effect of yogic training on lower leg muscle activation was analyzed across three specific asanas: Poornna Titali Asana, Utthita Trikonasana, and Padanguli Shakti Vikasaka. Paired-samples t-tests were conducted to compare pre- and post-intervention EMG values of four muscles: Adductor Longus, Gracilis, Gastrocnemius, and Soleus in 15 participants from the experimental group.

Adductor Longus
Across all three asanas, no statistically significant differences were observed in Adductor Longus activation. Although a notable decrease in mean activation was recorded during Padanguli Shakti Vikasaka (M = -62.58, p = 0.245), it did not reach significance. In Poornna Titali Asana (p = 0.896) and Utthita Trikonasana (p = 0.543), differences were minimal and not significant.

Gracilis
A statistically significant decrease in Gracilis activation was found in Utthita Trikonasana (M = -14.59, t(14) = -2.805, p = 0.014), indicating a meaningful effect of the yoga intervention on this muscle during that asana. No significant differences were observed in Poornna Titali (p = 0.593) or Padanguli Shakti Vikasaka (p = 0.799).

Gastrocnemius
The Gastrocnemius muscle showed a highly significant decrease in activation during Padanguli Shakti Vikasaka (M = -18.47, t(14) = -3.483, p = 0.004). No statistically significant changes were seen in Poornna Titali (p = 0.318) or Utthita Trikonasana (p = 0.162), despite some observable fluctuations in mean values.

Soleus
The Soleus muscle did not exhibit any significant changes across any of the three asanas. Mean differences ranged from M = -11.41 in Utthita Trikonasana to M = 10.54 in Poornna Titali, but p-values remained above 0.05 throughout (p = 0.271 to 0.772), suggesting no meaningful EMG changes as a result of the intervention.

Conclusion
The results indicate that among the tested asanas:
Utthita Trikonasana significantly reduces activity in the Gracilis, implying potential benefits in reducing adductor strain or activation. Padanguli Shakti Vikasaka significantly reduces Gastrocnemius activity, making it potentially beneficial for stretching or rehabilitating this muscle. Other muscle-asana combinations did not show significant effects, possibly due to individual variability or insufficient stimulus intensity. These findings suggest a muscle-specific and posture-specific influence of yoga asanas on lower limb muscle activity. This can help in therapeutic yoga prescription, particularly for targeting or relieving specific muscle groups. However, the relatively small sample size (n = 15) and high standard deviations in some conditions warrant cautious interpretation and highlight the need for further research with larger cohorts and EMG normalization techniques.

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