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Activity of Periarticular Hip Musculature during Yoga in Patients with Hip Pain: A Descriptive Study of a Case Series

Adler KL[1], Kenney R[1], Messing S[2] and Giordano BD[1]

[1]University of Rochester Medical Center, Department of Orthopaedics and Rehabilitation, Rochester, USA
[2]Department of Biostatistics and Computational Biology, University of Rochester Medical Center, USA

Abstract

Objective: Yoga is a popular form of exercise that promotes mind-body wellness and has recently been touted as a modality that may be well tolerated by patients with orthopaedic conditions. Paradoxically, yoga may exacerbate pain and dysfunction in certain populations, as poses often require prolonged activation of periarticular hip musculature to optimize stability, balance, and posture. The purpose of this study was to evaluate muscular activation patterns in subjects with hip pain during select yoga poses, hypothesizing that yoga participants with hip pain demonstrate poor ability to maintain muscular contractility necessary for pelvic stability.

Methods: Women with and without hip pain, who regularly participate in yoga, were evaluated using surface electromyography (SEMG) while performing common yoga poses. Each participant performed 30 s holds of three poses. To introduce the element of fatigue, the three poses were repeated in the original order, immediately following 20 repetitions of side-lying hip abduction.

Results: Subjects with hip pain demonstrated decreased muscular activation of the Gluteus Medius (p=0.0008), Gluteus Maximus (p<0.0001), Adductor Longus (p=0.0003) and External Obliques (p<0.0001). In healthy subjects, EMG activity of these muscles during yoga did not change (p=0.6387, 0.9954, 0.9740, 0.4878 respectively). Baseline amplitudes between groups were not significantly different (p=0.1725), although the Gluteus Medius amplitude was suggestive of a difference as it approached significance (p=0.0707).

Conclusion: Patients with hip pain undergo more rapid periarticular muscular fatigue than control subjects. They demonstrate increased muscular dysfunction when performing weight bearing yoga poses, therefore, should be appropriately counselled regarding the potential risk of symptomatic exacerbation and possible counterproductive effects of participation.

Keywords: Electromyography; Hip; Orthopaedics; Yoga; Muscle fatigue; Pain

Introduction

Yoga is a popular form of exercise that promotes overall health and wellbeing. Some endorse yoga as an effective alternative exercise strategy for patients with physically limiting orthopaedic conditions [1,2]. Despite its promise as a restorative element of a total body wellness program, yoga may cause discomfort at the hip in some individuals [3-5]. Yoga postures often require forceful, sustained, and controlled muscular contractions, and may induce muscular fatigue [6]. Specifically, single leg tasks require increased knee and hip abductor forces, while common double leg poses, such as Warrior II, require an addiction moment greater than that elicited with walking [7]. The practice of yoga requires a balance of flexibility, strength, and endurance, which over time have been reported to challenge tissues at their weakness point and lead to injury [5]. In weight bearing positions, many yoga poses require the prolonged use of periarticular hip musculature to provide stability.

Muscular activation patterns during yoga have been evaluated in many joints to better understand variations across skill level however; the role of these patterns has not yet been investigated in the presence of musculoskeletal pathology [8]. Detecting similarities in muscular firing patterns of those whom experience pain may allow clinicians to better address hip pathology.

The etiology of hip pain during yoga is not understood, but is suspected to be a result of muscular imbalances, requiring assistance from agonistic muscles. The purpose of this study is to better understand the activation patterns of periarticular hip musculature during select yoga poses in normal individuals and to compare these values with patients who experience hip pain during yoga. We hypothesize that yoga participants with hip pain demonstrate poor ability to maintain muscular contractility necessary for pelvic stability. Evaluating periarticular muscle activation patterns about the hip during common yoga poses may lead to an improved understanding of the various muscular contributions essential for postural control and serve as a guide for activity recommendations and rehabilitative strategies.

Methods

Participants

Institutional review board approval was granted for this study. Five women whom reported to an orthopaedic surgeon for evaluation of hip pain during yoga were recruited to serve as clinical participants for this study. Women invited to participate in the clinical group reported hip pain during yoga and had radiographic evidence of femoroacetabular

***Corresponding author:** Adler KL, University of Rochester Medical Center, Department of Orthopaedics and Rehabilitation, Rochester, USA, Tel: 585-341-9150; Fax: 585-276-2986; E-mail: Kelly_Adler@urmc.rochester.edu

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impingement. Four women whom regularly participate in yoga, but report no complaints of hip pain were recruited to serve as control subjects. All subjects provided written consent prior to data collection. Enrolled hip pain during yoga, with a clinical diagnosis of symptomatic femoroacetabular impingement and associated chondrolabral injury, were selected for study participation. Four women without complaints of hip pain during yoga also provided written consent and volunteered to serve as control subjects. All enrolled volunteers were required to participate in at least 1 hour of supervised yoga per week, for at minimum the past 6 months. In the clinical group (Group 1), participants reported hip pain equal to or greater than 5/10 on the Visual Analog Scale for pain during yoga, for a minimum of 6 weeks. Exclusion criteria included a history of prior lower extremity or low back surgery, acute lower extremity, pelvic or spine injury within 1 year, acetabular dysplasia, and adhesive capsulitis of the hip joint, pregnancy, or cerebral concussion within the last 6 months. In addition, the control group (Group 2) was required to be free of hip, knee, or low back pain during yoga.

Testing procedures

A medical hip questionnaire was used to screen participants for exclusion criteria. Gluteus medius (GMed), gluteus maximus (GMax), adductor group (ADD) and oblique (OBL) activity was measured using surface electromyography (sEMG), a non-invasive testing method to detect and record muscular activity. A Bagnoli-4 EMG System (DelSys Inc., Boston, MA, USA) that amplified at a gain of 1000 was used with four active sensors that were adhered to the skin using 4cm electrodes with a double-sided adhesive interface. The authors acknowledge the risk of crosstalk between electrodes in the setting of sEMG, therefore, extra caution was used in the application of the electrodes to reduce this risk. Electrodes, the sEMG electrodes were placed parallel to the muscle fiber orientation, superficial to the targeted muscles, which were verified with palpation and isolated manual resistance. A ground electrode was placed on the anterior aspect of the medial malleolus on the testing limb. Before electrode placement, the skin was shaved if needed, debrided via light rubbing with a coarse surface, and cleansed with isopropyl alcohol to minimize skin impedance. Signals were sampled at 1000 Hz and digitized with a 16-bit A/D board (National Instruments, Austin, TX) and EMGWorks 3.0 software (DelSys Inc., Boston, MA, USA).

In a controlled laboratory setting, the subjects were asked to perform a 5 s static single-leg stance (SLS), with their arms abducted to 90 degrees, elbows fully extended, with the contralateral knee and hip flexed to 90 degrees. The root mean square of the EMG signal (rmsEMG) was collected from the second to fourth second of the SLS. An average of 3 repetitions was used for data analysis (Figures 1-3). The 3 yoga poses, Tree, Standing Pigeon and Warrior II were reviewed with each subject to ensure her understanding. The poses in the testing protocol were familiar to all participants, as expected, as they are commonly practiced in yoga routines of all skill levels. Following a 2 min resting period, the 3 yoga poses were performed in afore mentioned order. Each pose was held for 30 s, with the rmsEMG collected from the fifth to twenty-sixth second. Data were normalized using the average rsmEMG SLS values. At the completion of the Warrior II pose, 20 repetitions of side-lying hip abduction were performed. The testing protocol was then concluded with immediate performance of the three poses, in the original order. The testing protocol was discontinued immediately if pain exceeded tolerable levels for the subject.

Figure 1: Tree pose.

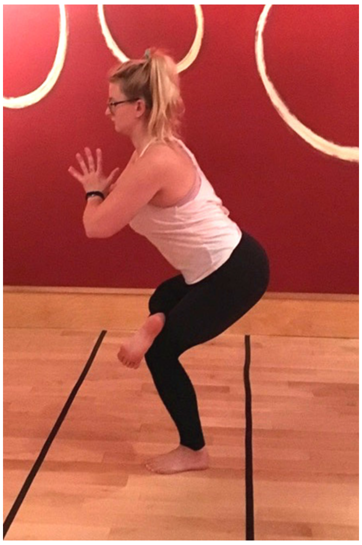

Figure 2: Standing pigeon pose.

Figure 3: Warrior II pose.

Statistical Analyses

To determine sample size needs, and with little information about the expected amplitudes given the exploratory nature of this study, we assumed that the control group, post-fatigue, would have a decrease in magnitude with values approaching a control group mean value of 30 and SD of 7. We further assumed that the control group, pre-fatigue, would have amplitude in the range of 6-10 points higher. With two repetitions for each of the three poses (6 repeated measures per muscle), five patients with a pre-post 0.15 correlation and with alpha=0.05, would provide 71% power to detect an effect size difference of 0.8 (a difference of six points) in amplitude. A difference of seven points (an EFD of 1.0) would provide 83% power and an eight-point difference would have 90% power to reject the null hypothesis.

Baseline amplitude differences were evaluated for each study group, muscle and group by muscle with an analysis of variance using a linear mixed-effects model. Amplitudes established following baseline were normalized by dividing obtained measures by their baseline values. An analysis of variance employing a linear mixed-effects model using the robust sandwich to estimate, permitting fitting of a model that might contain heteroscedastic residuals and violation of assumed distribution, to account for the correlated data introduced by the repeated muscle testing was used to evaluate differences between the study groups, time of testing (pre vs. post fatigue), interaction of study group and time, as well as the interaction of study group, time, and muscle. Comparisons were assessed subsequent to the overall analysis, adjusting for all variables in the model. All tests were two-sided and conducted at the 5% significance level. Analyses were carried out using SAS/STAT software, Version 9.4 of the SAS System (Copyright© 2002-2012, SAS Institute Inc.) on a Windows 7 platform.

Results

Our analysis, based on 4 control group members (mean age=37.8 ± 11.6; mean BMI=23.23 ± 1.66) and 5 treatment group members (mean age=42 ± 13.66; mean BMI=23.6 ± 2.5), used multiple observations measured for the subjects for four muscles, three poses and two different time points. The group difference were deemed not clinically important nor were they statistically significantly different for age (pt-test=0.64 and pWilcoxon=0.71) or BMI (pt-test=0.81 and pWilcoxon=0.62).

As anticipated, baseline values differed between the four muscles ($p<0.0001$). Study group ($p=0.1837$) and muscle by study group interaction ($p=0.2947$) did not differ. We had hypothesized that there would be a difference between the groups for the Gluteus Medius and while this difference was strongly suggestive ($p=0.0707$), it failed to achieve significance (Table 1).

Following the hip abduction exercise, the interaction terms supported the differences for the clinical and control groups, in both pre and post values within each group and for post exercise values between the groups (Table 2). The clinical group showed significantly decreased amplitudes following exercise for all muscles while the control group did not. Differences between the study groups were present post exercise, but not pre exercise, as was the case in the baseline comparisons. Although not significantly different, quite possibly due to small sample size, overall pre-exercise differences between groups were suggestive; with the control group demonstrating increased muscular activity.

	Clinical (Hip Pain)		Control		
Muscle	**Mean**	**Standard Error***	**Mean**	**Standard Error***	**p-value**
Adductor	34.799	1.8529	29.275	3.2847	0.1463
Obliques	35.895	2.2036	30.817	2.7703	0.1548
Gluteus Maximus	43.164	2.7221	36.203	4.1678	0.1653
Gluteus Medius	43.001	3.8109	34.131	3.6403	0.0957

*Robust sandwich estimate

Table 1: Group differences in baseline amplitudes.

Discussion

This study compared the activity of periarticular hip musculature during common yoga poses in a healthy population, with individuals who experience hip pain during yoga. Despite its popularity as a low-impact, restorative form of exercise, findings from this study suggest that yoga may lead to paradoxical counterproductive effects in individuals with hip pain or dysfunction. This study supports suggests that muscular imbalances, as a result of pain inhibition, early onset fatigue, and compensatory strategies, is a probable contributor to pain within this population.

Following the testing protocol, Group 2 did not display significant changes in periarticular muscular contributions, while Group 1 demonstrated global muscular fatigue evidenced by decreased amplitude on EMG testing. Decreased muscular output was noted for GMed, GMax, ADD and OBL. Prior studies have excluded anatomic and structural variations as a result of similar muscular deficits [9].

Studies that have investigated the association between strength and hip pain, suggest abductor dysfunction is a significant precursor to musculoskeletal dysfunction [10-12]. At stance, the iliotibial band (ITB) is under variable tension, depending on the degree of knee flexion and abduction [13,14]. In the presence of core weakness, hip abductor fatigue, and structural malalignment, recruitment of periarticular hip musculature may be dynamically altered to accommodate excess tension placed on the ITB [15,16]. This increased tension limits ability of the Tensor Fascia Latae (TFL) to contribute to lower extremity

	Group	Mean	SE*	Group	Mean	SE*	p-value
Adductor	Control Post	1.0234	0.01926	Control Pre	1.0241	0.00874	0.9475
Obliques	Control Post	0.9884	0.01019	Control Pre	1.0033	0.00306	0.1674
Gluteus Maximus	Control Post	1.0112	0.01584	Control Pre	1.0113	0.00824	0.9929
Gluteus Medius	Control Post	0.9719	0.01818	Control Pre	0.9820	0.00905	0.3577
Adductor	Clinical Post	0.8828	0.01721	Clinical Pre	0.9525	0.01447	<0.0001
Obliques	Clinical Post	0.8748	0.01754	Clinical Pre	0.9591	0.01070	<0.0001
Gluteus Maximus	Clinical Post	0.8929	0.02497	Clinical Pre	0.9878	0.03139	<0.0001
Gluteus Medius	Clinical Post	0.8235	0.04374	Control Pre	0.8885	0.04595	0.0103

*Robust sandwich estimate

Table 2: Adjusted group differences pre and post hip abduction exercise.

control and requires increased efforts from the GMed [17]. This explanation supports the findings of this study, and rationale for altered activity of gluteus medius in the presence of muscular fatigue. Female subjects have been shown to exhibit an increased adductor moment during gait, presumed to be due to gender specific differences in pelvic morphology. An eccentric Gluteal contraction resists excessive frontal plane movement and enhances lower extremity neuromuscular control [18,19]. Therefore, a greater moment at the knee would elicit heightened activity of the abductors at baseline. These alterations in gait-induced force vectors may introduce abductor weakness and fatigue [15,18,20-22]. Similar force vectors are also experienced during yoga poses that place increased demands on periarticuar hip musculature.

Yoga participants, who experience pain during activity, may display impaired muscular activity as a result of pain inhibition [23-25]. GMed dysfunction has been shown to result from arthrogenic muscular inhibition due to pain and reflex inhibition, caused by spasm within the highly innervated myotendinous units surrounding the capsule [26,27]. Specifically, in the presence of pain, GMed recruitment may decrease while performing functional tasks that challenge lower extremity muscular endurance [28]. In this study, the presence of pain differentiates the two groups, allowing pain inhibition to be considered to have influenced muscular activity in the clinical group.

During baseline stationary single-leg stance, EMG recordings from Group 1 suggested increased use of GMed, when compared to the pain-free participants. This increase in force output is suspected to be associated with compensatory changes in muscular activation and neural drive [29]. The GMed, a primary pelvic and hip stabilizer, is often recruited in pain avoidance strategies in the presence of hip pathology [30]. This places the muscle in a position of vulnerability to weakness and inhibition, and therefore it is frequently implicated as a contributor to dynamic hip dysfunction [31]. It is plausible that the force generated is a maladaptive strategy to maintain postural stability in the presence of core weakness [31,32]. Studies evaluating low back pain have identified a correlation between pain and decreased GMed resting time between contractions [33]. When subjects were enrolled in an exercise program that aimed to improve endurance of lumbar musculature, as an attempt to unload the constant load absorbed by the GMed, activation was equalized and pain resolved [33]. The reported results imply increased GMed tone may be an indicator of poor pelvic stability and pathological patterns of co-contraction. Increased EMG amplitude has also been shown to reflect poor regulation from the central nervous system (CNS). In subjects with hip osteoarthritis, augmented GMed activity patterns were believed to correlate with an inability of the CNS to grade the difficulty of the task, therefore utilizing greater than necessary force, as suggested during baseline measurements in this study [29]. Continued dependence on excessive GMed firing for postural control may reduce the fund of contractile input, reserved for tasks with greater physical demand. In this study elevated baseline levels in the clinical group, suggesting increased GMed resting tone, may help explain decreased activity following the testing protocol. An excessive co-contraction at rest and during simple functional tasks may induce early onset muscle fatigue [31]. Identification of muscular dysfunction during SLS in individuals with pain provides evidence that fatigue may impair muscular activity, and exacerbate pain following participation in more demanding functional tasks.

Periarticular hip musculature works in concert to maintain joint congruity and evenly balance joint reactive forces across the articular cartilage. In a healthy joint, the abductor complex contributes to dynamic force coupling and exerts a compressive force across the hip joint that may exceed three to four times an individual's body weight [34,35]. Muscular insufficiencies due to chronic pain and fatigue of the GMed may induce suboptimal loading properties that have potential to negatively impact joint health over time [36-39]. Long-term consequences of compensatory strategies involving abductor musculature may include magnification of joint loading secondary to hip and pelvic co-contractions [39]. An alteration in muscular activation concerning the hip should be addressed, to reduce compressive forces and disruption of the efficient force couple that may accelerate degenerative disease due to abnormal contact forces [40].

This study utilized a small convenience sample. As such, the generalizability of the findings is limited to the volunteer participants in a yoga class study. The findings of this study suggest that participation in yoga may not represent an ideal activity choice for individuals with hip pain. While modifications can be difficult due to the constant transition of poses within a routine, continued participation may be considered if activity can be adapted to reduce symptomatic complaints. Successful execution of certain yoga poses require sustained periarticular muscular contractions, which were found to be challenging for patients with hip pain. Dynamic movements are regulated by force coupling, which is disrupted by muscular imbalances. This dysfunction suggests there would be an unequal distribution of torque and stress across the joint, which could lead to muscular dysfunction, degenerative joint disease and symptomatic intra-articular pathology. Fatigue may compromise postural control, resulting in decreased balance and muscular inefficiency while maintaining prolonged contractions. In a fatigued state, double leg tasks would be more appropriate, where hip abductor activity remains submaximal [15].

Given these findings, it is recommended that treatment programs for hip pain consider all contributory causes. The therapeutic strategy should incorporate a broad understanding of weakness and dysfunction within the lumbo-pelvic-hip complex to develop an individualized lower extremity strengthening and muscular rebalancing program. Often hip pain is attributed to hip abductor weakness, with prescribed treatment focusing on abductor strengthening. While the rationale of such a program may be to improve hip abductor strength to tolerate increased demands, the findings of this study suggest that alternative strategies may be more beneficial for individuals with pre-existing hip abductor dysfunction and high resting tone. Previously discussed valgus knee moments may be intensified during single-leg movements, as a result of hip adduction and internal rotation [41]. In subjects with a propensity towards fatigue overload of the periarticular hip musculature, single leg balance training and isolated abductor strengthening may be counterproductive, and should be discouraged [42]. When treating such cases, restructuring rehabilitation programs to restore proper muscular activation patterns may provide a more durable solution. Specific rehabilitation strategies are beyond the scope of this paper, however, has previously been explained in detail [43].

Limitations

While the current study provides information for the muscles that were evaluated, EMG evaluations are not without limitations. The possible contribution of accessory trunk muscles that were not included in this study must be considered. Evaluation of these muscles in patients with weakness and impairment of the hip and pelvis may provide additional information regarding muscular imbalances. All possible measures were taken to reduce the concern for crosstalk, however due to the proximity of adjacent musculature it cannot be confirmed this was entirely eliminated. It is also recognized that the sample size was small, which may limit application of findings to a more broad population.

Conclusion

This study provides valuable insight into the muscular activity patterns employed by participants during common yoga poses. An improved understanding of the root of hip pain and the role of periarticular hip musculature co-activation patterns in the presence of muscle imbalances has been suggested. These findings may help the clinician determine whether participation in yoga should be modified or contraindicated as a method of wellness and long term fitness goals. Additional findings may also be applicable in rehabilitation strategies concerning hip pathology.

Clinical Recommendations

This study provides valuable insight into the muscular activation patterns employed by participants during common yoga poses. An improved understanding of the root of hip pain and the role of periarticular hip musculature co-activation patterns in the presence of muscle imbalances has been suggested. These findings may be used to assist the clinician in providing activity recommendations, with the consideration that modifications may need to be employed or yoga may be contraindicated as a method of wellness and long-term fitness goals in certain individuals. There is concern that modification alone may not be suitable option, due to constant transitions between poses and lack of opportunity to rest in the practice of modern day yoga. Treatment programs for hip pain should consider all contributory causes and incorporate a broad understanding of weakness and dysfunction within the lumbo-pelvic-hip complex. Restructuring rehabilitation programs to restore proper muscular activation patterns may provide a more durable solution (SORT Grade C).

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