KTO Karatay Üniversitesi Sağlık Bilimleri Dergisi ISSN: 2717-8501 KTO Karatay University Journal of Health Sciences
Geliş Tarihi:13/11/2024 Kabul Tarihi:01/12/2024
Yıl 2024 | Cilt 5 | Sayı 3 **Araştırma Makalesi/ Research Article** DOI: 10.59244/ktokusbd.1583906

KTO KARATAY ÜNİVERSİTESİ
SAĞLIK BİLİMLERİ DERGİSİ
KTOKÜSB-D

The Effect of Physical Yoga Poses on Anterior and Posterior Myofascial Chain Activity in Elderly Individuals

Yaşlı Bireylerde Fiziksel Yoga Pozisyonlarının Ön ve Arka Miyofasyal Zincir Aktivitesi Üzerine Etkisi

Hasan Gerçek[1], Hazal Sarak Küçükosmanoğlu[2], Çağlar Soylu[3], Ayça Aytar[4], Necmiye Ün Yıldırım[5], Aydan Aytar[6]

ABSTRACT

Objective: The structures in the human body are biomechanically and anatomically interconnected. The aim of this study was to determine and compare the effects of the Chair Pose, Sage Marichi Pose C, Warrior 2 Pose, and Extended Triangle Pose on Adductor Longus (AL), External Oblique (EO), Biceps Femoris (BF), and Latissimus Dorsi (LD) muscle activity in young, older, and elderly individuals.
Materials and Methods: Six elderly individuals were included in the study. Participants' myofascial chain activity evaluated with surface electromyography (EMG) during Utkatasana, Virabhadrasana II, Utthita Trikonasana and Marichyasana C pose.
Results: The participants' Adductor Longus, External Oblique, Biceps Femoris, and Latissimus Dorsi % maximum voluntary isometric contraction values did not show significant difference. During the Utkatasana pose, the Latissimus Dorsi showed greater electromyography (EMG) activity compared to AL, EQ, and BF. During the Virabhadrasana II pose, EQ had greater EMG activity compared to AL, LD, and BF. During the Utthita Trikonasana pose, LD had greater EMG activity compared to AL, EQ, and BF. During the Marichyasana C pose, BF had greater EMG activity compared to LD, EQ, and AL. **Conclusion**: This study showed with biomechanical data that muscle groups containing anterior and posterior myofascial chains work more effectively in different yoga poses and emphasized the importance of a holistic approach in elderly individuals.
Keywords: Elderly, electromyography, maximum voluntary isometric contraction, Yoga

ÖZET

Amaç: İnsan vücudundaki yapılar biyomekanik ve anatomik olarak birbirine bağlıdır. Bu çalışmanın amacı Utkatasana, Virabhadrasana II, Utthita Trikonasana ve Marichyasana C duruşlarının genç, yaşlı ve ileri yaştaki bireylerde Adduktor Longus (AL), Eksternal Oblik (EO), Biceps Femoris (BF) ve Latissimus Dorsi (LD) kas aktivitesi üzerindeki etkilerini belirlemek ve karşılaştırmaktır. **Gereç ve Yöntem:** Çalışmaya altı yaşlı birey dahil edilmiştir. Katılımcıların miyofasyal zincir aktivitesi Utkatasana, Virabhadrasana II, Utthita Trikonasana ve Marichyasana C duruşları sırasında yüzey elektromiyografisi (EMG) ile değerlendirilmiştir. **Bulgular:** Katılımcıların Adductor Longus, Eksternal Oblik, Biceps Femoris ve Latissimus Dorsi % maksimum istemli izometrik kasılma değerleri anlamlı farklılık göstermemiştir. Utkatasana duruşu sırasında Latissimus Dorsi, AL, EQ ve BF'ye kıyasla daha fazla elektromiyografi (EMG) aktivitesi göstermiştir. Virabhadrasana II duruşu sırasında EQ, AL, LD ve BF'ye kıyasla daha fazla EMG aktivitesine sahipti. Utthita Trikonasana duruşu sırasında LD, AL, EQ ve BF'ye kıyasla daha fazla EMG aktivitesine sahipti. Marichyasana C duruşu sırasında BF, LD, EQ ve AL'ye kıyasla daha fazla EMG aktivitesine sahipti. **Sonuç:** Bu çalışma, anterior ve posterior miyofasiyal zincirleri içeren kas gruplarının farklı yoga pozlarında daha etkin çalıştığını biyomekanik verilerle göstermiş ve yaşlı bireylerde bütüncül yaklaşımın önemini vurgulamıştır.
Anahtar kelimeler: Elektromiyografi, maksimum istemli izometrik kasılma, yaşlılar, Yoga

[1]Öğr. Gör., KTO Karatay Üniversitesi, Sağlık Hizmetleri Meslek Yüksekokulu, Fizyoterapi Programı, Konya, Türkiye. ORCID: 0000-0001-7459-4452. **(Sorumlu Yazar)**
[2] Uzman, Sağlık Bilimleri Üniversitesi, Gülhane Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Doktora Programı, Ankara, Türkiye. ORCID: 0000-0002-1154-536X
[3] Dr. Öğr. Üyesi, Sağlık Bilimleri Üniversitesi, Gülhane Fizyoterapi ve Rehabilitasyon Fakültesi, Ortopedik Fizyoterapi ve Rehabilitasyon ABD, Ankara, Türkiye. ORCID: 0000-0002-1524-6295
[4]Doç. Dr., Başkent Üniversitesi, Sağlık Hizmetleri Meslek Yüksekokulu, Fizyoterapi Programı, Ankara Türkiye. ORCID: 0000-0002-4089-5406
[5]Prof. Dr., Sağlık Bilimleri Üniversitesi, Gülhane Fizyoterapi ve Rehabilitasyon Fakültesi, Ortopedik Fizyoterapi ve Rehabilitasyon ABD, Ankara, Türkiye. ORCID: 0000-0002-5527-4290
[6]Prof. Dr., Sağlık Bilimleri Üniversitesi, Gülhane Fizyoterapi ve Rehabilitasyon Fakültesi, Ortopedik Fizyoterapi ve Rehabilitasyon ABD, Ankara, Türkiye. 0000-0002-2631-0109
Sorumlu Yazar: Hasan Gerçek, KTO Karatay Üniversitesi, Sağlık Hizmetleri Meslek Yüksekokulu, Fizyoterapi Programı, Konya, Türkiye, e-posta: hasangercek42@gmail.com

INTRODUCTION

Aging is a lifelong process beginning in the intrauterine period and progressing through chronological, biological, psychological, and social changes. By 2025, the global elderly population is projected to exceed one billion (Gürler & Bayraktar, 2021).

The human body's structures are biomechanically and anatomically interconnected. The kinetic chain model views the body as a chain of linked joints that work together to produce a desired function (Myers, 2020). Mechanical tension in one part of the body can cause adaptations in other areas without disrupting form or function (Myers, 2020). Myers identified anterior and posterior oblique myofascial chains, with the anterior chain including the hip flexors, adductors, obliques, serratus anterior, and rhomboids, and the posterior chain comprising the gastrocnemius, hamstring, gluteal, latissimus dorsi, and pectoral muscles (Myers, 2020). The reciprocal movement of the extremities during walking or cross-pattern movements demonstrates the kinetic chain in action. Research has shown force transfer between various structures such as the plantar fascia and Achilles tendon, pelvic/hamstring movement and the gastrocnemius, and the latissimus dorsi and contralateral gluteus maximus (Krause et al., 2016). Understanding the ability to alter fascia's mechanical properties is important for therapy and education, making myofascial chain concepts relevant in movement-related fields (Bordoni & Myers, 2020).

Aging leads to continuous changes in skeletal muscles, connective tissues, and the nervous system, impairing the ability to perform daily activities like walking, which affects health-related quality of life (Reid & Fielding, 2012). This results in decreased physical performance and affects cognitive and psychological states (Zullo et al., 2020). Environmental, pharmacological, and accident-related factors also change, making severe consequences, particularly falls, inevitable. Falls are a major public health issue, often leading to injuries such as subdural hematomas, fractures, and head trauma in the elderly, contributing to increased mortality (Hopewell et al., 2018).

Yoga practices have surged in recent years as people seek solutions for health and well-being (Liu et al., 2021). Beyond its potential to address cardiovascular, respiratory, urogenital, and nervous system disorders in the elderly, yoga has been shown to positively impact cognitive function and mental health (Chobe et al., 2020; Mooventhan & Nivethitha, 2017). Regular yoga improves muscle strength and reduces psychological symptoms, ultimately improving quality of life (Shin, 2021). Yoga integrates body, mind, and spirit through physical exertion, incorporating elements such as breathing exercises (pranayama), asanas, balance, and meditation (Liu et al., 2021).

During asanas, gravity tends to rotate the limbs and pull the body down. Muscles and ligaments help counteract these effects (Salem et al., 2013a). Standing poses like Marichyasana C, Utkatasana, Virabhadrasana 2, and Utthita Trikonasana (Kumar et al., 2018; Liu et al., 2021) activate muscles in both the anterior and posterior oblique myofascial chains.

Asana's physical demands are often measured using electromyography (EMG) (Salem et al., 2013a). Surface electromyography (sEMG), along with dynamometry, ultrasonography, and magnetic resonance imaging, is widely used to assess muscle activity. Its non-invasive nature and ability to record signals from multiple muscles simultaneously make it ideal for dynamic tests in fields like medicine, rehabilitation, sports, and ergonomics (Mortka et al., 2020).

The aim of this study was to determine and compare the effects of the Chair Pose, Sage Marichi Pose C, Warrior 2 Pose, and Extended Triangle Pose on EOA, AL, LD, and BF muscle activity in young, older, and elderly individuals.

MATERIALS AND METHODS

This study was carried out between May 2022 and June 2022 in the laboratory of Gulhane Health Sciences University Faculty of Physiotherapy and Rehabilitation. The study included one male and five female elderly volunteers, constituting six participants in total, who were 65 years of age or older, did not exercise on a high level, did not take long walks, did not practice yoga, and were residents of the community. The study excluded individuals with active angina, uncontrolled hypertension, elevated resting heart rate or respiratory rate, known rheumatic and musculoskeletal disease. After obtaining approval from the Pharmaceutical and Non-Pharmaceutical Research Ethics Committee at KTO Karatay University, the protocol was registered on http://clinicaltrials.gov (NCT 05400850).

Sample Size

The minimum required sample size for the study was calculated using the G*Power (G*Power Version 3.0.10, Franz Faul, Universität Kiel, Germany) program. The sample size was calculated as 6 participants at a type-I error rate of 0.05 and with 90% power (Muyor et al., 2020).

Intervention

Yoga asanas were performed by the participants under the supervision of a physiotherapist. EMG measurements were recorded during the asanas by another physiotherapist with five years of experience in kinesiological EMG evaluation. The order of the asanas performed by the participants was determined randomly in the computer program. The participants stood statically for 15 seconds in each of the asanas and repeated the movements three times. During the practice, when the individuals found it difficult to perform the steps, the asanas were modified using equipment such as belts, blocks, and pillows, and safety precautions were taken. Warrior 2 and Sage Marichi Pose C stances were evaluated for both extremities separately.

Chair Pose (Utkatasana): The individuals stood with their feet approximately hip-width apart, a fist's distance from the knees. While performing the asana, it was ensured that the knees were facing directly ahead with a slight posterior pelvic tilt, and the shoulders were pressed down and back. The arms were extended upwards at the level of the head, and the person fixed their gaze towards the ground at a certain point to maintain balance (Figure 1 a). If the distance between the two legs could not be maintained, a block was placed between the knees.

Sage Marichi Pose C (Marichyasana C): Sitting on the sitting bones with the legs extended forward, an axial extension was requested by extending the spine upwards. When the trunk was not standing upright, a thin pillow was placed under the ischial tuberosity, an anterior pelvic tilt was achieved, and the trunk was brought to a slightly more upright position. One leg was bent as much as possible, and the knee joint was pressed to the floor with the extended ankle dorsiflexed and the patella pulled upwards. While performing this posture, the abdomen was strongly pulled upwards and inwards. Finally, the cervical vertebrae were rotated, and the posture was then finished as it was started. When both sitting bones had an asymmetric position, the asymmetric hip was elevated with the aid of a blanket (Figure 1 b).

Warrior 2 Pose (Virabhadrasana II): With the hip joint of the front leg in external rotation, the toes were kept facing forward, and the front heel was in line with the heel of the rear foot. The knee was flexed 90 degrees directly above the ankle. The hips were lowered to the ground, a slight posterior pelvic tilt was applied, and the spine was axially extended (Figure 1 c).

Extended Triangle Pose (Utthita Trikonasana): While in the Warrior 2 pose, the individual stretched with their front arm extended, extending the front knee. Then, they got support from the floor if they could with their front hand. If they could not, they got support from over their ankle or from a block. They extended their other hand upwards so that it was in line with their initially used arm. At the same time, they extended forward with the top of their head, causing their spine to be axially extended (Figure 1 d).

Figure 1. a) Utkatasana, b) Marichyasana C, c) Virabhadrasana II, d) Utthita Trikonasana

Surface EMG Measurement
The muscle activations of the individuals' were evaluated for the contralateral external oblique abdominal and ipsilateral adductor longus muscles of the anterior oblique myofascial chain lines and contralateral latissimus dorsi and ipsilateral biceps femoris long head muscles of the posterior oblique myofascial chain lines using the sEMG method (Figure 2).

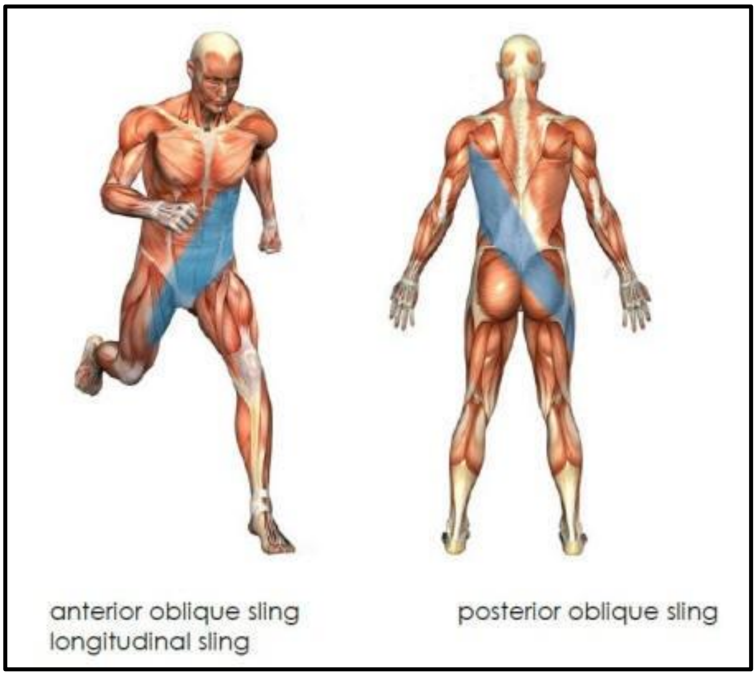

Figure 2. Anterior and posterior oblique myofascial chain lines (Myers, 2020)

EMG activity was recorded from muscles using a multichannel EMG device (Noraxon Ultium EMG sensor system, Noraxon USA, Inc., Scottsdale, Arizona; sampling frequency 4000 Hz/channel; gain: 1000; signal-to-noise ratio <1 μV RMS; CMRR: < -100 dB; input impedance >100 mΩ). Prior to electrode placement, skin impedance was reduced using alcohol-soaked gauze. Bipolar Ag/AgCl surface electrodes were positioned 2 cm apart by the same examiner, parallel to muscle fibers, following the SENIAM guidelines (Stegeman & Hermens, 2007). The electrode placements are detailed in Figure 3.

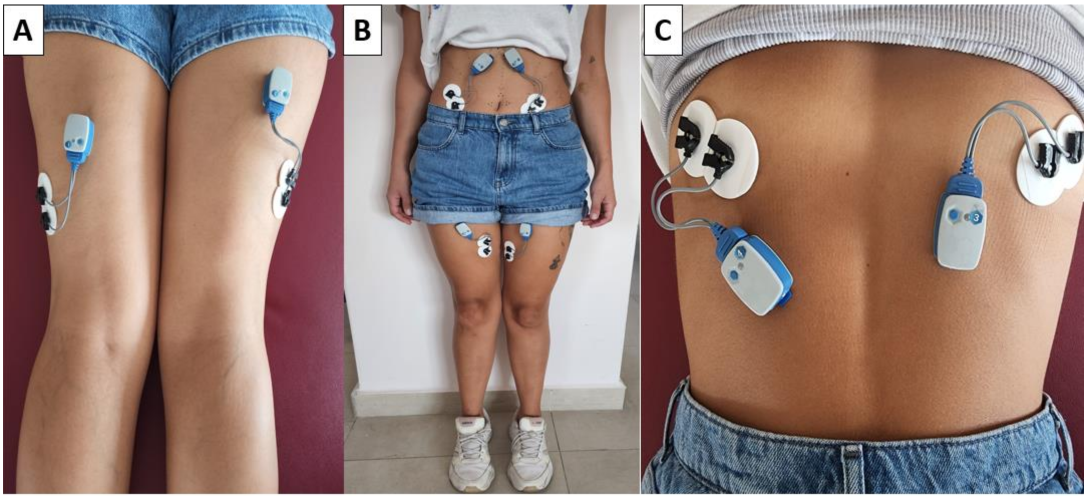

Figure 3. Surface EMG electrode placements. (A) biceps femoris long head; (B) external oblique abdominal and adductor longus muscles; (C) latissimus dorsi

- External oblique: 15 cm lateral to the umbilicus, parallel to the muscle fibers.
- Biceps Femoris: Parallel to the muscle fibers, to the midpoint of the line between the tuber ischium and the lateral condyle of the tibia.
- Latissimus dorsi: Half the distance between the vertebral spine and the edge of the lateral side of the trunk, 4 cm below the angle of the lower scapula, 25 degrees oblique to the muscle fibers (Borges et al., 2018).
- Adductor longus: Proximal at 1/3 of the line between the pubic tubercle and the attachment point on the femur, parallel to the muscle fibers (Serner et al., 2014).

For the measurement of the maximum voluntary isometric contraction values (MVIC) of the examined muscle groups, separate EMG measurements were performed with 3 repetitions of maximal contraction for 5 seconds with a 30-second rest period between each contraction. The MVIC value of each muscle was measured with 3 repetitions, a 1-minute rest period was given between the repetitions, and the average of the MVIC measurements taken with 3 repetitions was recorded. The positions determined for the MVIC measurements were as follows (Halaki & Gi, 2012).

- External oblique: Resistance was applied over the shoulder while trying to rotate the trunk in the supine position with the knees flexed to 90°.
- Biceps Femoris: Resistance was applied over the ankle in the prone position with the knee flexed to 45°.
- Latissimus dorsi: While standing with the trunk flexed and supported on the bed, the arm to be tested was applied resistance over the elbow to the shoulder extension with the elbow flexed (Beaudette et al., 2014).
- Adductor longus: Supine bilateral hip adduction was performed with the hips and knees in full extension and a ball placed between the knees.

Afterwards, during the exercises of Utkatasana, Marichyasana C, Virabhadrasana 2, and Utthita Trikonasana, sEMG measurements were taken from the same muscle groups for 15 seconds. During the EMG measurements, videos were recorded using a Logitech C920 camera (Logitech, Lausanne, Switzerland) at 30 frames/second, and the camera was activated synchronously with the measurement device. The muscle activation rates during the yoga exercises were determined according to the maximum voluntary contraction for each muscle [amount of activity muscular activation / Maximal voluntary contraction* 100 (%Maximum voluntary contraction)]. The sampling rate of the EMG signal was set at 1000 Hz. A 20 Hz Butterworth High-Pass filter was applied to all EMG recordings, RMS 100 ms was selected for smoothing, and the signals were filtered. The measured data were analyzed using the Noraxon MyoResearch XP software (version 1.08; Noraxon Inc, Scottsdale, AZ).

Statistical Analysis

The SPSS Statistics for Windows Version 25.0 (2017; IBM Corp., Armonk, NY, USA) software package was used to analyze the data. The homogeneity of the variances for all parameters were analyzed with Shapiro-Wilk and Levene’s tests and histograms. Mixed-design analysis of variance (ANOVA) and the Bonferroni-Dunn test, which is a multiple comparisons test, were used in the analyses to make a general evaluation between the muscles and yoga poses. Normalized EMG data (using RMS) were used for all statistical analyses. The models were run separately for each of the poses and muscles. A preset α level of $p<0.05$ was selected to determine statistical significance.

RESULTS

The six healthy participants (5 female, 1 male) had a mean age of 66.00±1.55 years and a mean body mass index of 22.46±1.66 kg/m^2.

The participants' Adductor Longus (AL), External Oblique (EO), Biceps Femoris (BF), and Latissimus Dorsi (LD) % maximum voluntary isometric contraction values were similar ($p>0.05$) (Figure 4)

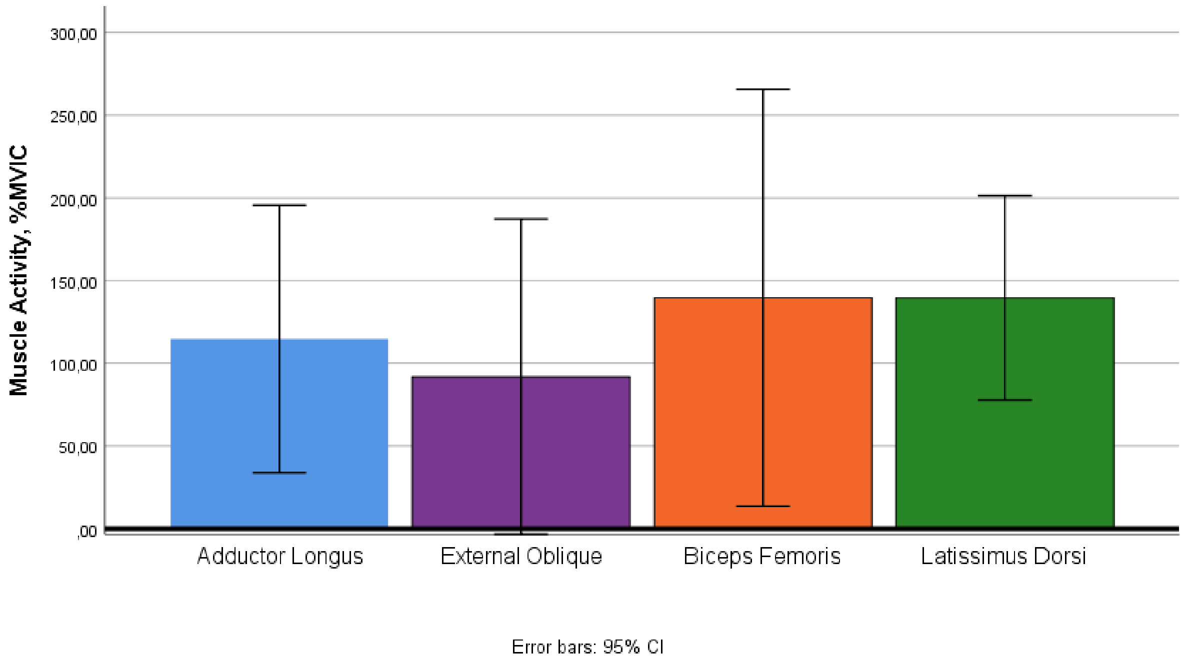

Figure 4. Participants' % maximum voluntary isometric contraction values

During the Utkatasana pose, Latissimus Dorsi showed greater EMG activity compared to AL (p=0.017, 95% CI: 2.138-16.595), EQ (p<0.001, 95% CI: 16.179-29.521), and BF (p<0.001, 95% CI: 30.031-41.656) (Figure 1). During the Virabhadrasana II pose, EQ had greater EMG activity compared to AL (p=0.046, 95% CI: 0.202-18.332), LD (p=0.005, 95% CI: 5.608-21.126), and BF (p=0.003, 95% CI: 8.842-27.258). During the Utthita Trikonasana pose, LD had greater EMG activity compared to AL (p=0.004, 95% CI: 4.960-17.907), EQ (p<0.001, 95% CI: 13.156-26.944), and BF (p<0.001, 95% CI: 15.993-33.440). During the Marichyasana C pose, BF had greater EMG activity compared to LD (p=0.027, 95% CI: 1.748-23.085), EQ (p=0.001, 95% CI: 17.855-44.811), and AL (p<0.001, 95% CI: 24.276-45.658) (Figure 5).

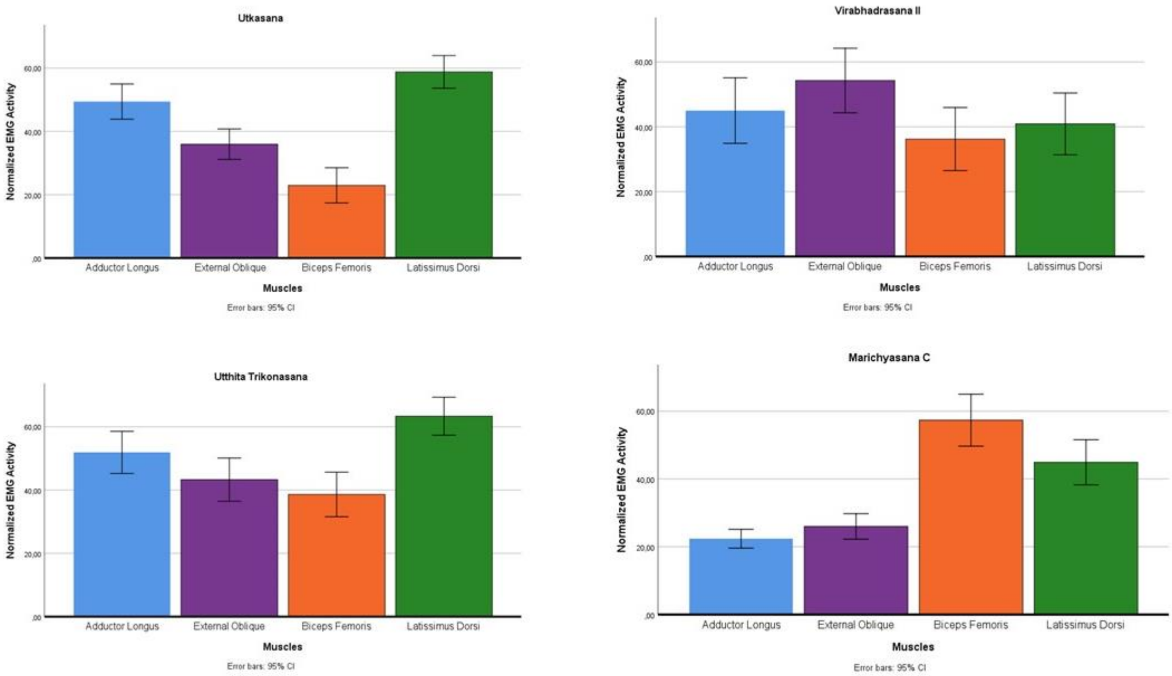

Figure 5. Yoga poses and muscle activities

The adductor longus had greater EMG activity levels in the Utkatasana, Virabhadrasana II, and Utthita Trikonasana poses compared to the Marichyasana C pose ($p<0.01$). The Utkatasana, Virabhadrasana II, and Utthita Trikonasana poses had similar Adductor longus EMG activity levels ($p>0.05$). The Virabhadrasana II, Marichyasana C, and Utkatasana poses had greater External oblique EMG activity levels compared to the Utthita Trikonasana pose ($p<0.05$). The Virabhadrasana II and Marichyasana C poses did not show significantly different EMG activity levels ($p>0.05$). The Marichyasana C and Virabhadrasana II poses had greater Biceps femoris EMG activity levels compared to the Utthita Trikonasana and Utkatasana poses ($p<0.05$). The Marichyasana C and Virabhadrasana II poses did not show significantly different EMG activity levels ($p>0.05$). The Utthita Trikonasana and Utkatasana poses had greater Latissimus dorsi EMG activity levels compared to the Marichyasana C and Virabhadrasana II poses ($p<0.05$). The Utthita Trikonasana and Utkatasana poses did not have significantly different EMG activity levels ($p>0.05$) (Figure 6).

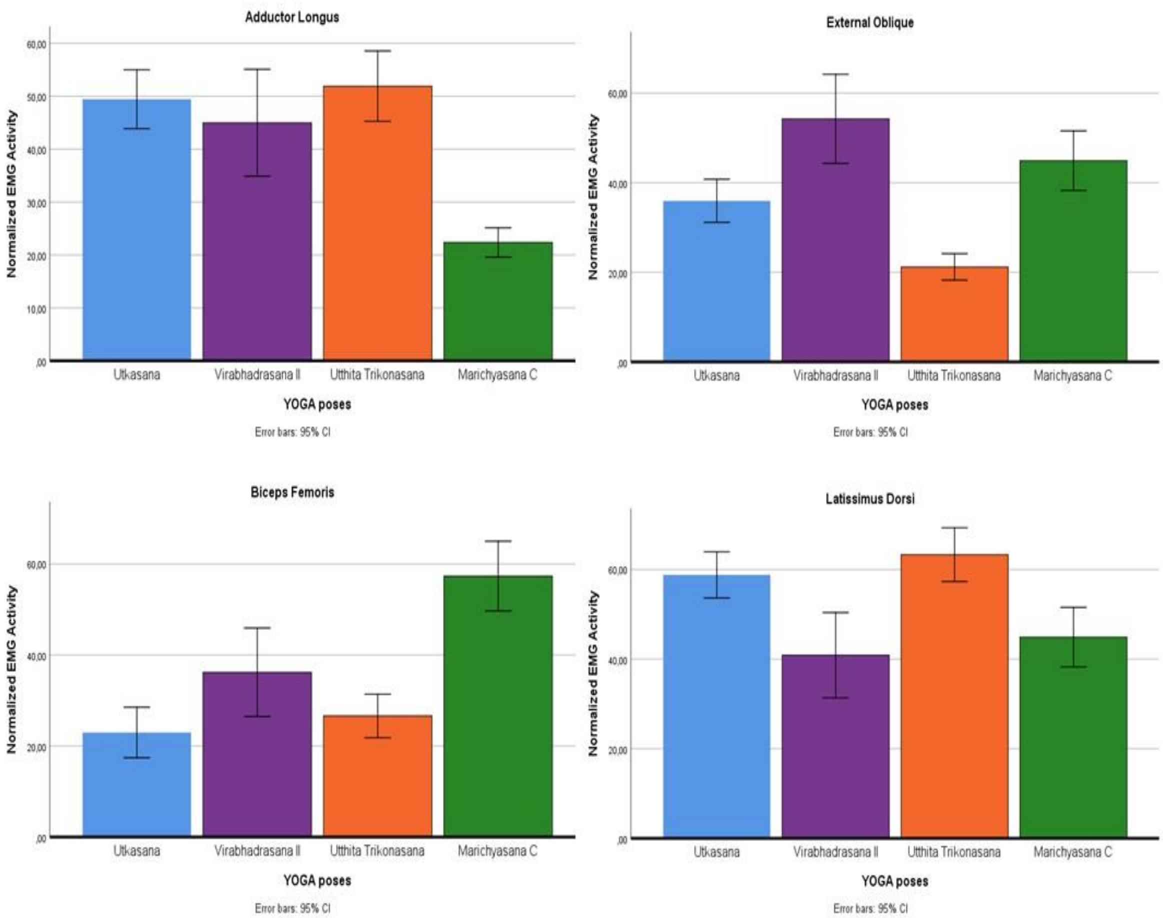

Figure 6. Muscle EMG activities during yoga poses

DISCUSSION

The purpose of this study was to examine the activation of the adductor longus, external oblique, biceps femoris, and latissimus dorsi muscles in the Utkatasana, Virabhadrasana II, Utthita Trikonasana, and Marichyasana C poses and determine which poses affected muscle activation more. Latissimus dorsi muscle activity was higher in the Utkatasana and Utthita Trikonasana poses, external oblique muscle activity was higher in the Virabhadrasana II pose, and Biceps femoris muscle activity was higher in the Marichyasana pose.

In the Utkatasana pose, the highest EMG activity was found in LD, and the lowest EMG activity was in BF. The highest EMG activity is in the erector spinae and tibialis anterior, and the lowest EMG activity is in the gastrocnemius and BF (Kelley et al., 2019; Salem et al., 2013b). The EMG activation of the lumbar extensors is more important in controlling trunk flexion in the Chair Pose than in other yoga poses (Down-Facing Dog and Warrior 1) (Bolgla et al., 2018). The function of the LD may explain why the EMG activation of the LD in Chair Posture is higher than the activation of other muscles. Low outputs in BF in the Chair Pose can be explained by the slight anterior displacement of the person's center of mass. In another study, the EO muscle had moderate EMG activation in the Chair Pose (Ni et al., 2014), which was similar in our study. The activation of this muscle creates resistance to hip flexion so that the pelvis can be stabilized and provides a stable foundation for the trunk. We think that the effects of the Utkatasana pose on the anterior and posterior oblique myofascial chains were similar, so the Utkatasana pose can be used to strengthen both oblique myofascial chains.

In the Marichyasana C pose, BF and LD had higher EMG activity levels. This result showed that the Marichyasana C pose is more effective on the posterior cruciate chain activity and more effective than the other 3 poses for strengthening the posterior oblique myofascial chain.

In the Virabhadrasana II pose, the highest EMG activity was found in EO and AL, while the lowest EMG activity was found in LD and BF. Another study also showed the highest EMG activity in the Quadriceps and the lowest EMG activity in the gastrocnemius muscles during the Virabhadrasana II pose (Salem et al., 2013b). This result demonstrated that the Warrior 2 pose is more effective on the anterior oblique myofascial chain. This pose can be used to strengthen the anterior oblique myofascial chain.

In the Utthita Trikonasana pose, the highest activity was in LD, and the lowest activity was in BF. We think that the Utthita Trikonasana pose has a similar effect on both oblique myofascial chains. Hence, it is a pose that can be used to increase the activation of both oblique myofascial chains.

This study had some limitations. First, the sample size was very small. Therefore, it is not easy to assume that the findings of these data apply to all populations. Second, 5 of the tested participants were female, and 1 was male. Thus, more research with male participants is needed. Finally, only the surface EMG method was used to determine muscle activity. In this case, it is difficult to determine that the recorded activity actually came from isolated muscles.

CONCLUSION

As age progresses, the possibility of problems caused by internal and external factors such as musculoskeletal system diseases, heart diseases, hypertension, osteoporosis, osteoarthritis, muscle weakness, fatigue, loss of sensation, and falls increases (Chobe et al., 2020). Our findings showed that different yoga poses were more effective on different muscle groups.

Considering the importance of prescribing appropriate exercises to the person, we think that it is important to evaluate the strength of elderly individuals first and train them with the appropriate yoga poses.

Conflict of Interest

There is no conflict of interest between the authors.

Financial Support

The authors declare that they received no financial support for this study.

Author Contributions

Research Idea/Concept: HG, AA, AA
Research Design: HG, HSK, ÇS
Supervision/Consultancy: AA, NUY, AA
Data Collection and/or Processing: HSK, ÇS
Analysis and/or Interpretation of Data: HG
Literature Review: HG, HSK

Article Writing: HG, HSK, ÇS
Critical Review: AA, NUY, AA

REFERENCES

Beaudette, S. M., Unni, R., & Brown, S. H. M. (2014). Electromyographic assessment of isometric and dynamic activation characteristics of the latissimus dorsi muscle. *Journal of Electromyography and Kinesiology, 24*(3), 430–436. https://doi.org/10.1016/j.jelekin.2014.03.006

Bolgla, L. A., Amodio, L., Archer, K., Estes, J., Leung, R., Magoni, K., Mullikin, A., Roberts, D., Weems, M., & Beazley, D. (2018). Trunk and hip muscle activation during yoga poses: Do sex-differences exist? *Complementary Therapies in Clinical Practice*, *31*, 256–261. https://doi.org/10.1016/j.ctcp.2018.03.006

Bordoni, B., & Myers, T. (2020). A Review of the Theoretical Fascial Models: Biotensegrity, Fascintegrity, and Myofascial Chains. *Cureus*, *12*(2), e7092. https://doi.org/10.7759/cureus.7092

Borges, E., Mezêncio, B., Pinho, J., Soncin, R., Barbosa, J., Araujo, F., Gianolla, F., Amadio, C., & Serrão, J. (2018). Resistance training acute session: Pectoralis major, latissimus dorsi and triceps brachii electromyographic activity. *Journal of Physical Education and Sport*, *18*(2), 648–653. https://doi.org/10.7752/jpes.2018.02095

Chobe, S., Chobe, M., Metri, K., Patra, S. K., & Nagaratna, R. (2020). Impact of Yoga on cognition and mental health among elderly: A systematic review. *Complementary Therapies in Medicine*, *52*, 102421. https://doi.org/10.1016/j.ctim.2020.102421

Gürler, H., & Bayraktar, N. (2021). The effectiveness of a recurrent fall prevention program applied to elderly people undergoing fracture treatment. *International Journal of Orthopaedic and Trauma Nursing*, *40*, 100820. https://doi.org/10.1016/j.ijotn.2020.100820

Halaki, M., & Ginn, K. (2012). Normalization of EMG Signals: To Normalize or Not to Normalize and What to Normalize to? In *Computational Intelligence in Electromyography Analysis - A Perspective on Current Applications and Future Challenges*. InTech. https://doi.org/10.5772/49957

Hopewell, S., Adedire, O., Copsey, B. J., Boniface, G. J., Sherrington, C., Clemson, L., Close, J. C. T., & Lamb, S. E. (2018). Multifactorial and multiple component interventions for preventing falls in older people living in the community. *Cochrane Database of Systematic Reviews*, 7(7), CD012221. https://doi.org/10.1002/14651858.CD012221.pub2

Kelley, K. K., Giannico, K., Lesnett, G., & Romano, A. (2019). A comparison of EMG output of four lower extremity muscles during selected yoga postures. *Journal of Bodywork and Movement Therapies*, *23*(2), 329–333. https://doi.org/10.1016/j.jbmt.2019.01.005

Krause, F., Wilke, J., Vogt, L., & Banzer, W. (2016). Intermuscular force transmission along myofascial chains: A systematic review. *Journal of Anatomy*, *228*(6), 910–918. https://doi.org/10.1111/joa.12464

Kumar, A., Kapse, R., Paul, N., Vanjare, A., & Omkar, S. (2018). Musculoskeletal modeling and analysis of trikonasana. *International Journal of Yoga*, *11*(3), 201-207. https://doi.org/10.4103/ijoy.ijoy_1_18

Liu, A-M., Chu, I-H., Lin, H-T., Liang, J-M., Hsu, H-T., & Wu, W-L. (2021). Training benefits and injury risks of standing yoga applied in musculoskeletal problems: Lower limb biomechanical analysis. *International Journal of Environmental Research and Public Health*, 18(16), 8402. https://doi.org/10.3390/ijerph18168402

Mooventhan, A., & Nivethitha, L. (2017). Evidence based effects of yoga practice on various health related problems of elderly people: A review. *Journal of Bodywork and Movement Therapies*, 21(4), 1028-1032. https://doi.org/10.1016/j.jbmt.2017.01.004

Mortka, K., Wierteł-Krawczuk, A., & Lisiński, P. (2020). Muscle activity detectors—surface electromyography in the evaluation of abductor hallucis muscle. *Sensors (Basel)*, *20*(8), 2162. https://doi.org/10.3390/s20082162

Muyor, J. M., Martín-Fuentes, I., Rodríguez-Ridao, D., & Antequera-Vique, J. A. (2020). Electromyographic activity in the gluteus medius, gluteus maximus, biceps femoris, vastus lateralis, vastus medialis and rectus femoris during the Monopodal Squat, Forward Lunge and Lateral Step-Up exercises. *PLoS One*, 15(4), e0230841. https://doi.org/10.1371/journal.pone.0230841

Myers, T. W. (2020). Anatomy Trains e-book: Myofascial meridians for manual therapists and movement professionals. In *Elsevier Health Sciences*. https://doi.org/10.1016/s1479-2354(03)00039-7

Ni, M., Mooney, K., Harriell, K., Balachandran, A., & Signorile, J. (2014). Core muscle function during specific yoga poses. *Complementary Therapies in Medicine*, *22*(2), 235–243. https://doi.org/10.1016/j.ctim.2014.01.007

Reid, K. F., & Fielding, R. A. (2012). Skeletal muscle power: A critical determinant of physical functioning in older adults. *Exercise and Sport Sciences Reviews*, *40*(1), 4–12. https://doi.org/10.1097/JES.0b013e31823b5f13

Salem, G. J., Yu, S. S-Y., Wang, M.-Y., Samarawickrame, S., Hashish, R., Azen, S. P., & Greendale, G. A. (2013a). Physical Demand Profiles of Hatha Yoga Postures Performed by Older Adults. *Evidence-Based Complementary and Alternative Medicine*, 2013, 165763. https://doi.org/10.1155/2013/165763

Salem, G. J., Yu, S. S. Y., Wang, M. Y., Samarawickrame, S., Hashish, R., Azen, S. P., & Greendale, G. A. (2013b). Physical demand profiles of Hatha yoga postures performed by older adults. *Evidence-Based Complementary and Alternative Medicine*, 2013, 165763. https://doi.org/10.1155/2013/165763

Serner, A., Jakobsen, M. D., Andersen, L. L., Hölmich, P., Sundstrup, E., & Thorborg, K. (2014). EMG evaluation of hip adduction exercises for soccer players: Implications for exercise selection in prevention and treatment of groin injuries. *British Journal of Sports Medicine*, *48*(14), 1108–1114. https://doi.org/10.1136/bjsports-2012-091746

Shin, S. (2021). Meta-analysis of the effect of yoga practice on physical fitness in the elderly. *International Journal of Environmental Research and Public Health*. 18(21), 11663. https://doi.org/10.3390/ijerph182111663

Stegeman, D., & Hermens, H. (2007). Standards for surface electromyography: The European project Surface EMG for non-invasive assessment of muscles (SENIAM). *Línea).*, 108–112.

Zullo, A., Fleckenstein, J., Schleip, R., Hoppe, K., Wearing, S., & Klingler, W. (2020). Structural and Functional Changes in the Coupling of Fascial Tissue, Skeletal Muscle, and Nerves During Aging. *Frontiers in Physiology*, 11, 592. https://doi.org/10.3389/fphys.2020.00592