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ORIGINAL ARTICLE

An Anatomical Illustrated Analysis of Yoga Postures Targeting the Back and Spine Through Cadaveric Study of Back Musculature

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Abstract

Back pain is a debilitating lifestyle disease that affects a large proportion of the world's population at some point in their life. Absences from work due to this have a huge economic impact on the patient, their employer and the healthcare providers who seek to support their recovery. Unfortunately, back pain is often resistant to treatment and intervention, therefore alternative therapies such as Yoga are being explored. Within the literature, five Yoga postures were identified to be associated with reduced back pain in patients suffering from Chronic lower back pain. To aid anatomical analysis of these Yoga postures, a detailed cadaveric dissection of the back was performed to understand the action and activity of the musculature in these postures. In order to cohesively present the findings, unique hand-drawn illustrations were used to depict the musculature found to be highly active with each Yoga posture, with the erector spinae muscles appearing prominent throughout. The combined approach of using hand-drawn illustrations with cadaveric dissection to present the anatomical analysis has allowed a seamless understanding of complex anatomical concepts alongside the nuances of intricate gross anatomy. This study highlights the importance of the inclusion of cadaveric dissection as a pedagogical tool in medical curriculum through exploring the anatomical basis of Yoga, also allowing the possibility of using the workings of Yoga to aid anatomical teaching. A greater understanding of this may help guide personalized Yoga regimes, which may allow alternative therapies to become integrated into the primary care setting.

Key Words: *Cadaveric dissection; Anatomical illustrations; Back musculature; Yoga postures; Chronic lower back pain*

Introduction

Cadaveric dissection is a hands-on method for learning anatomy that is considered by many as being the gold standard mode for teaching this important discipline [1]. This three-dimensional approach to study human architecture provides an important link between structure and function, yet also allows an appreciation of natural anatomical variation [2]. For decades, dissection has formed a fundamental basis of anatomical training received by students at medical schools around the world [2]. Although some believe that dissection is an old fashioned practice with the dawn of many sophisticated on-line digital anatomy packages [3], it still remains that medical students prefer to learn anatomy by gross dissection and practical hands-on techniques [2,4]. Hence, the literature emphasizes that studying anatomy by dissection remains the gold standard. Learning anatomy through dissection not only aids learning of

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the intricacies and possible variations of the human body, but also acquaints students with important aspects of death, confidentiality, empathy and respect, indispensable for medical professionals [2-4].

In 2015, there were 32 registered medical schools in the UK, nineteen of them offering cadaver dissection, however only twelve (60%) of these offered it as their main teaching method [4]. By 2019, the number of UK Medical Schools increased to 40, with 22 reportedly offering cadaveric dissection although now only one-third (thirteen) of these use it as their main mode of teaching anatomy [5]. These statistics clearly demonstrate the decline in medical schools offering cadaveric dissection and this is not only limited to the UK but is seen as a worldwide downwards trend [6]. Contributing factors to this include a reduction in curriculum time available to the basic medical sciences, including anatomy, with the introduction of new competency course components [4,7]. A decline in the numbers of qualified full-time anatomy teachers and a hike in financial costs of running a dissection laboratory has meant that some medical schools have moved away from dissection either in part or have completely eliminated this mode of teaching [4,7]. This decline has come at a time when some clinicians have voiced concern over the level of anatomical knowledge medical students possess at graduation and in their early clinical placements [8,9]. Anatomical areas in particular that are felt to be suboptimal include those pertaining to Musculoskeletal (MSK) medicine. This is of clinical concern as MSK problems account for a large proportion (15-30%) of all primary care visits [10,11].

A clear example of how MSK knowledge is vital to clinicians is when considering the incidence of Chronic Lower Back Pain (CLBP). Back pain is a major lifestyle dysfunction or disorder that occurs at least once in the lifetime of about 75-85% of the world's population and can be broadly classified into the area where the pain is experienced; namely Cervical, Thoracic or Lumbosacral segments [12]. Although all these types of pain can be self-debilitating, lower back pain in the Lumbosacral region is often found resistant to treatment and intervention [13]. Due to this resistance to traditional therapies, other interventions are being widely investigated for CLBP. A growing body of literature focusses on Yoga, an ancient Indian practice, that uses physical movement and stretching in the form of postures in combination with relaxed breathing to treat back ailments such as CLBP [14,15]. Yoga is known to have medium-large size effect on pain symptoms and functional stability of CLBP patients [16].

In this study, we report how a systematic and detailed cadaveric dissection has been used to investigate the individual back musculature associated with Yoga postures or Asanas (Sanskrit terminology) reported to ameliorate pain associated with CLBP. To conduct this, Yoga postures like Uttanasana, Bhujangasana, Shalabhasana, Balasana and Sethubandhasana were studied extensively in this article. Uttanasana and Balasana are forward-bends, utilizing gravity in order to attain the full benefits of the posture, targeting hip flexibility in combination with spinal extension and flexion [17]. While Uttanasana is performed standing, Balasana is conducted in a relaxing foetal position. Bhujangasana, Shalabhasana and Sethubandhasana are backbends that target the vertebral column more intensely than forward-bends, requiring powerful contraction and stability of the musculature [17,18].

To highlight the importance of anatomical knowledge as a basis of Yoga practice, hand-drawn explanatory illustrations of the asanas have been produced to help aid visual communication by effectively isolating different anatomical structures exposed by dissection [19]. By combining cadaveric dissection with a detailed review of Yoga postures associated with improving pain of CLBP sufferers, this unique study hopes to provide insight to practitioners and patients alike through an illustrative media.

Materials and Methods

A mixed-method systematic review was carried out to study the efficiency of specific Yoga postures for pain relief in CLBP patients. Thirty-one quantitative studies met the inclusion criteria which comprised randomized controlled trials, comparison trials and trials that involved sections of society (e.g. veterans and nurses). These studies were published between January 2005 and December 2019. Of these investigations, approximately a quarter i.e. eight studies [20-27] provided specific details with definitive evidence of Yoga postures and were therefore used in this anatomical study. Five Yoga postures (Table 1) were selected from these eight studies in order to present the significance and action of the musculature isolated in the cadaveric dissection.

Cadaveric Dissection

A systematic dissection of the posterior aspect of the trunk, inferior to the neck and superior to the gluteal region, of an elderly female cadaver was performed to observe and illustrate back muscles active in specifically identified yoga postures. The dissection was based on a traditional regional dissection approach [28], which allowed extrinsic and intrinsic back muscles to be clearly isolated, maintaining the associated neurovasculature where possible.

Anatomical Illustrations

All stages of the dissection were documented and hand-drawn schematics were produced to effectively communicate the different anatomical structures that were isolated, which were directly linked to the five Yoga postures under consideration. The schematics were created in line with medical illustrations using the graphic app called Concepts on an iPad Pro with a second-generation Apple pencil. The purpose of using illustrations was to simplify complex scientific research and make it stimulating and easy to comprehend [19], aiding anatomical analysis of the Yoga postures.

Results

Understanding back musculature through cadaveric dissection

A detailed cadaveric dissection was performed to illustrate muscles used in key Yoga postures identified by the systematic literature search (Figure 1). Extrinsic musculature was isolated exposing the extrinsic superficial muscles; namely trapezius, latissimus dorsi, levator scapulae, rhomboid major and minor (Figure 1A to Figure 1D). Subsequently, the extrinsic intermediate muscles (serratus posterior superior and serratus posterior inferior) were isolated (Figure 1E and Figure 1F). The intrinsic back musculature (Figure 1G and Figure 1H), specifically the intrinsic intermediate musculature, was then isolated exposing iliocostalis, longissimus and spinalis muscles; all parts of the erector spinae muscle. Consequently, the intrinsic deep muscles [transversospinales] namely the spinalis and multifidus muscles were also exposed.

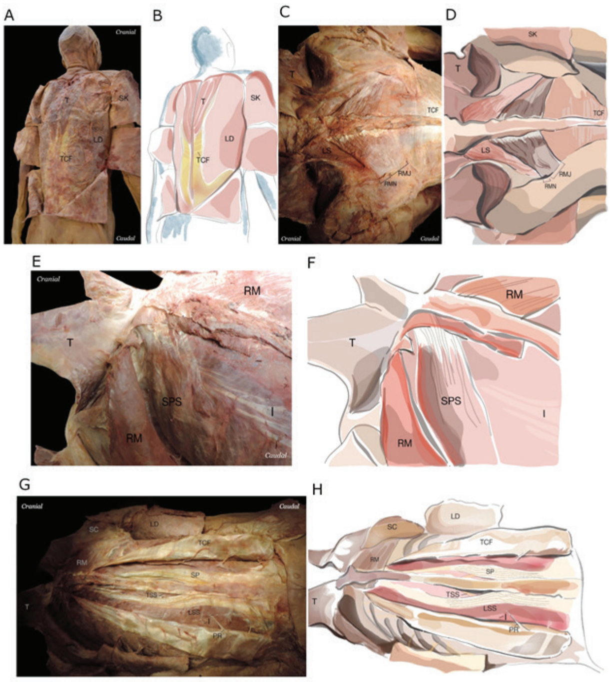

Figure 1) *A and B) Reflection of skin exposing extrinsic superficial musculature. C and D) Extrinsic superficial musculature. E and F) Extrinsic superficial and intermediate musculature. G and H) Intrinsic intermediate and deep musculature.*
T: Trapezius; LD: Latissimus Dorsi; TCF: Thoracolumbar Fascia; LS: Levator Scapulae; RM: Rhomboid Muscles; RMJ: Rhomboid Major; RMN: Rhomboid Minor; SPS: Serratus Posterior Superior; SC: Scapula; SP: Spinalis; I: Iliocostalis; LSS: Longissimus; PR: Posterior Rami; TSS: Transversospinales.

Anatomical analysis of Yoga postures

Using the findings from the eight reported studies [20-27] that studied the effectiveness of Yoga as a treatment for CLBP, five Yoga postures targeting the back musculature were identified; namely Uttanasana, Bhujangasana, Shalabhasana, Balasana and Sethubandhasana. Their definitions and involvement in back musculature were presented in Table 1. Yoga postures use isometric contraction and relaxation of various muscle groups in order to achieve focused body alignments, targeting one muscle compartment, or multiple ones at the same time [29]. Information on the muscles of the highest activity in each of the postures along with their targeted action is based on electromyographic analyses of different musculature reported in the literature [30-32]. Data highlighted in Table 1 illustrates how the erector spinae muscles show the highest activity in the postures commonly identified in this study. The erector spinae muscles' actions were two fold, acting to lengthen causing the musculature to straighten in forward bend postures (Uttanasana, Balasana) and contract causing the musculature to strengthen in backbend postures (Bhujangasana, Shalabhasana, Sethubandhasana) [33]. Hand-drawn figures (Figure 2) have been used to combine the targeted back musculature, as demonstrated in the cadaveric dissection, in relation to the five Yoga postures that have been reported to alleviate back pain in CLBP patients.

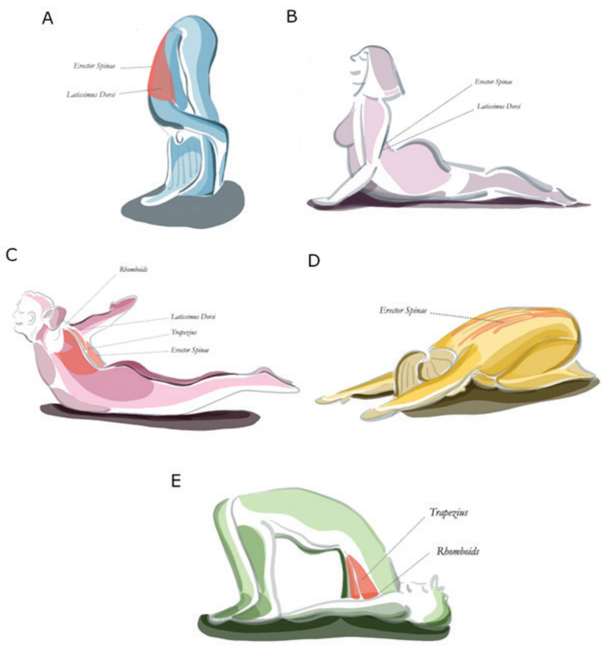

Figure 2) *Hand-drawn illustrations highlighting the active back muscles involved in five Yoga postures in correlation to the muscles identified in the cadaveric dissection, namely Uttanasana (A), Bhujangasana (B), Shalabhasana (C), Balasana (D), Sethubandhasana (E).*

TABLE 1
Involvement and activity of back muscles during five Yoga postures reported to decrease back pain in CLBP patients. Note the most active muscles involved in each of these postures (identified in the literature via electromyographic analyses) have been denoted *alongside a brief overview of their action [17,18,30-33].

Yoga posture	Description of yoga posture	Back muscles and their activity during named yoga posture
Uttanasana-Standing forward bend) (Figure 2A)	A standing forward bend posture aided by gravity, involving flexion and extension of the trunk	Erector Spinae (Spinalis)*: Stretch, lengthen. Multifidus*: Stability of spine and posture (Mild spinal flexion)
Bhujangasana-Cobra posture (Figure 2B)	A basic prone back-bending posture lifting the chest against gravity, with the palms placed directly under the shoulders.	Erector spinae* and transversospinalis (multifidus)*: Powerful contraction and strengthening. Serratus posterior superior*: Chest expansion. Latissimus dorsi: Internal arm rotation, thoracic back flexion, stability of posture.
Shalabhasana-Locust posture (Figure 2C)	A prone back-bending position, arms extended at about shoulder level with legs straight together. Legs and head kept as high as possible.	Intermediate deep muscles* and erector spinae*: Powerful contraction. Middle Trapezius: Lateral rotation in prone arm raise. Latissimus and rhomboids: Lengthening arm and upper back. Multifidus: Stability of spine
Balasana-Child's posture (Figure 2D)	A resting forward bend posture where the body settles into deep full spinal flexion and a slight cervical extension, aided by gravity.	Middle Trapezius*: causes shoulder abduction at 120-degree angle. Erector spinae: Stretch, lengthen (Neutral alignment due to simultaneous full spinal flexion and hip flexion/abduction).
Sethubandhasana-Bridge lumbar stretch posture (Figure 2E)	A supine inversion/backbend posture where gravity plays a key role. The scapulae are elevated to place the shoulders on the floor, allowing the chest to be lifted off the floor.	Erector spinae (longissimus thoracis*): Powerful contraction. Intrinsic deep muscles (multifudus*): Stability. Rhomboids: adductors of the scapulae. Levator scapulae: Press the scapulae into the floor. Trapezius: Adduct, elevate, medially rotate the scapulae.

Discussion

In this study two ancient disciplines, Yoga and cadaver dissection, have been interposed to give anatomical relevance to an alternative therapy for CLBP. Linking anatomy through cadaveric dissection to the evidence-basis of Yoga in back pain relief, helps reinstate the importance of cadaveric dissection as a pedagogical tool [2]. The combined approach of using hand-drawn illustrations with cadaveric dissection allows seamless understanding of complex ideas of dissection and the nuances of intricate gross anatomy. This study proposes how such an approach may be used to illustrate anatomical connections to other forms of alternative therapies that are growing both in terms of popularity and also credence.

The first-hand cadaveric dissection was instrumental in providing an in-depth knowledge of back musculature and gave a visual understanding of the muscles of high activity involved in specific Yoga postures. The most important back musculature found to be active among these common Yoga postures were the erector spinae muscles. It is known that CLBP patients often develop reduced trunk control and imbalanced pattern of longissimus muscles [34]. Thus, it is easy to see how counteracting this through Yoga postures targeting the erector spinae muscles could have beneficial effects for these patients [33-35].

Therefore, a greater understanding of the muscles active in yoga postures may allow more targeted Yoga regimes that are individually patient focused. Disseminating research in this context to the wider community is essential, since backpain is such a common lifestyle condition that patients seek treatment through multiple routes, including primary care and alternative therapies, such as Yoga. A Yoga instructor for example, would benefit from information regarding the musculoskeletal anatomy in order to help their student instill awareness of their body's capacity, strength and thereby guiding them to undertake modified postures. The importance of musculature anatomy for Yoga enthusiasts and instructors is clear and some institutes have begun to incorporate Yoga mechanisms to help teach anatomy [36]. There is arguably great scope to take this further and consider whether the anatomical understanding of Yoga could be taught in a wider context. Yoga's capacity to generate healing lies in its postures, but a lack of understanding on its effect on pain relief makes clinicians often skeptical about alternative therapies and their significance in treatment of pain [37]. As a result, it may be interesting to consider whether benefits would arise from integrating such teaching into a medical school curriculum to increase understanding of alternative therapies by providing anatomical inference.

Conclusion

The study used systematic cadaver dissection and detailed illustrations to elucidate important anatomical structures pertinent to Yoga postures that have been reported to improve pain in CLBP patients. In times when cadaveric dissection is becoming a demanding mode of teaching anatomy, this investigation provides evidence to show that anatomical results through dissection can give credibility to medical research, providing effective information to learners including students, anatomists, clinicians, patients and Yoga enthusiasts. A sound knowledge of anatomy and its application in specific back related Yoga postures has an impact on therapeutic interventions that may have once been considered non-conventional in treating back pain patients. The study also encourages Yoga to not be used solely as a practice, but also as a method to explain musculature anatomically, allowing its foray into medical curriculum. The futuristic approach would be the possibility of Yoga and similar alternative therapies to be integrated into primary care to improve the quality of life for patients.

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