ORIGINAL ARTICLE

Nr 2022;12 (4):594-599

Fascicle Orientation of Superficial Back Muscles Attached to the Posterior Layer of the Thoracolumbar Fascia: a Morphometric Study Using Human Cadavers

S. Marpalli[1], M. K. G. Rao[1], P. Venkatesan[2], B. M. George[1]

[1] *Division of Anatomy, Department of Basic Medical Sciences, Manipal Academy of Higher Education (MAHE), Manipal, India*

[2] *Department of Physiotherapy, Manipal College of Health Professions (Bangalore Campus), Manipal Academy of Higher Education (MAHE), Manipal, India*

CORRESPONDING AUTHOR:
Bincy M. George
Division of Anatomy
Department of Basic Medical Sciences
Manipal Academy of Higher Education
(MAHE)
Madhav Nagar, Manipal
Udupi District
Karnataka, India 576 104
E-mail: bincy.george@manipal.edu

DOI:
10.32098/mltj.04.2022.15

LEVEL OF EVIDENCE: 3

SUMMARY

Background. The posterior layer of the thoracolumbar fascia (PTLF) connecting the trunk, upper and lower limb muscles is a part of the deep fascia of the back of the trunk. It is the major myofascial linkage for myofascial force transmission. The present study reveals the fascicle orientation of the muscles namely gluteus maximus, latissimus dorsi, and lower trapezius muscles at different vertebral levels with respect to posterior layer of thoracolumbar fascia. Though the myofascial continuity between TLF and the muscle of the back is well documented, the information about orientation of the muscle fibers in relation to the myofascial linkage that ensures synchronization between them is lacking.

Materials and methods. Forty formalin embalmed healthy looking human cadavers were dissected and photographed. By using Image J software, myofascial linkage at different vertebral levels and the orientation of the muscle fascicles were documented.

Results. Mean angulation of trapezius muscle at T1 to T12 vertebral spines found decreased from 90°-10° at different vertebral levels. The angulation of latissimus dorsi muscle found decreased from 160° to 85° above downwards and that of gluteus maximus muscle 165° to 85°. No significant difference in the angulation of muscle fibres observed between left and right sides.

Conclusions. This study contributes novel information about the myofascial linkage between superficial back muscles at different vertebral levels, the orientation of these muscles and their fascial relationships. This data could be used for descriptive purposes and in further understanding of the biomechanics involved in movements of the back.

KEY WORDS

Fascicle orientation; lower trapezius; latissimus dorsi; gluteus maximus; biomechanics; movement of back.

INTRODUCTION

The posterior layer of the thoracolumbar fascia (PTLF) is attached to the spines and supraspinous ligaments of all lumbar and the sacral vertebrae, posterior crest of the ilium, lower 3 or 4 ribs, and to the tip of the scapula (1). The PTLF continues below with the fascia covering the gluteus maximus muscle. It also protects the extensor muscles of the vertebral column. The superficial muscles attached to PTLF are latissimus dorsi (LD), and gluteus maximus (GMx) and the lower fibers of trapezius (Tz) through interspinous ligaments. PTLF serves as a major fascial link between the trunk and both upper and lower extremities. PTLF regulates, facilitates, and restricts musculofascial function and load transfer for the body (2). The knowledge of the connection between the muscles and the fasciae are very important to understand the impairment of the musculoskeletal anatomy (3). The literature makes limited mention of this vertebral aponeurosis, biomechanical function in connection with the fascicle orientation of the muscles attached to it. The fascicle orientation will put light on the function and clinical role of the PTLF and the superficial back muscles. This study aims to examine the fascicle orientation of muscles attached to PTLF in order to elucidate its function and establish its usefulness with regard to clinical practice.

Fibers of the trapezius are divided into three groups: upper, middle, and lower (4). The upper fibers of the trapezius are attached to the ligamentum nuchae, and the middle and lower fibers are attached to the T1 to T12 vertebral spines and the interspinous ligaments. The latissimus dorsi muscle is attached to the spinous processes (T6 to S5), as well as the supraspinous ligament, via the PTLF. The gluteus maximus arises from the gluteal surface of the ilium, the PTLF, the sacrum, and the sacrotuberous ligament and is inserted into the gluteal tuberosity of the femur and to the iliotibial tract. As all these 3 muscles are attached to PTLF, it may affect the sensory feedback and thereby the neuromuscular control. In pathological conditions, this connection may contribute to altered biomechanics of the back of the trunk. For example, contracted fibers of latissimus dorsi are associated with the chronic shoulder pain and chronic low back pain (5).

In this study, the orientation and the angulation of the muscles attached to the PTLF are studied in the human cadavers. This data on myofascial continuity and orientation of muscle fascicle between the PTLF and the superficial back muscles will give insight to the synchronization between them. Proper knowledge of this myofascial connection and the fascicle orientation of the muscles is very important in the fascial manipulation technique for back pain of myofascial origin (6, 7). Thus, the aim of this study was to investigate the orientation and anatomical features of the muscles attached to PTLF.

MATERIALS AND METHODS

Forty formalin embalmed healthy looking human adult cadavers were obtained from the Department of Anatomy, Melaka Manipal Medical College, MAHE, Manipal. Institutional Ethical Committee approval (Registration No. ECR/146/Inst/KA/2013/RR16 – Date of approval: March 8, 2016) was taken prior to the study.

Cadaveric dissection

The skin of the back of the trunk of all the forty cadavers were removed using the guidelines given in the Cunningham's manual of practical anatomy (6). The myofascial continuity of posterior layer of TLF, namely trapezius, latissimus dorsi, and the gluteus maximus muscle on both sides were identified. Goniometer and metal caliper (accuracy ± 1°) were used for all the measurements. The orientation of fleshy fiber fascicles of gluteus maximus, latissimus dorsi and trapezius muscles were identified and documented at different vertebral levels. The vertical line passing through the spines of the vertebrae were considered as vertical axis. Horizontal lines passing through the spines of the vertebrae at the levels of T1, T2, T4, T6, T8, T10, T12, L1, L2, L3, L4, L5, S1, S2 and S3 were considered as horizontal axes. The dissected back of the trunk were photographed using Nikon 5100 digital camera without any special effect.

Image J analysis

Images obtained were uploaded to image-J software. The orientation of fleshy fiber fascicles of gluteus maximus, latissimus dorsi and trapezius muscles were at different vertebral level were analyzed and documented and the direction of the muscle fibers are mapped with the help of sketches.

RESULTS

Fascicle orientation of trapezius muscle

Figure 1 and **table I** show the angulation of fascicle of right and left trapezius muscles attached at T1, T2, T4, T6, T8, T10, and T12 vertebral levels. From T1 to T2, the angulation of the muscle fibers found increased bilaterally. Whereas from T4 to T12, the angulation of fibers was shown marked decrease on both sides. There was no significant difference observed in the angulation of trapezius muscle on right compared to the and left side.

Fascicle orientation of latissimus dorsi muscle

Figure 2 and **table II** show the angulation of fascicles of right and left latissimus dorsi muscles attached to PTLF at T10, T11, T12, L1, L2, L3, L4 vertebral levels. At T10, T11 and T12 vertebral levels the average angulation of the muscle fibers was 122.71° ± 2.31° on right side and 122.70° ± 2.31°on left side. In relation to PTLF, angulation of myofascial linkage from L1 to L4 vertebral levels decreases from 108.97° ± 2.53° to 85.87° ± 3.13° on the right side. There is no significant difference in the angulation of the latissimus dorsi on the left and right sides.

Fascicle orientation of gluteus maximus muscle

Figures 3, 4 and **table III** show the angulation of fascicle orientation of right and left gluteus maximus muscles. At L4 and L5 vertebral levels the angulation of the gluteus maximus

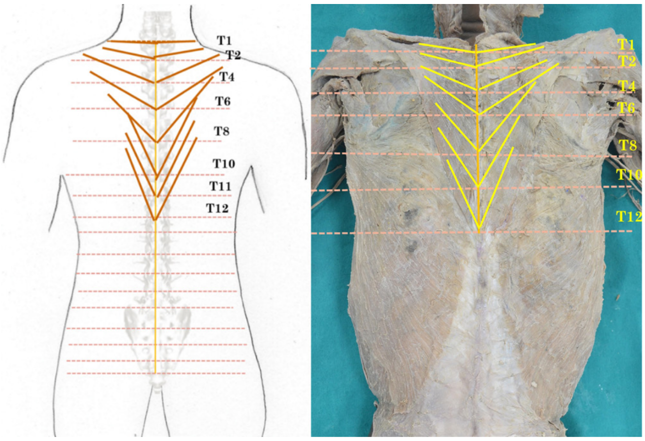

Figure 1. Schematic representation and the cadaveric photograph of back of the trunk showing the angulation of trapezius muscle on Right (R) and Left (L) sides at the spines of level of spines of T1, T2, T4, T6, T8, T10, T12 vertebrae.

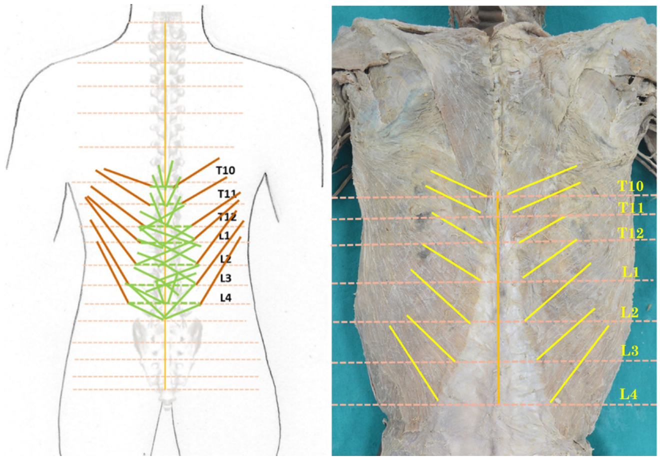

Figure 2. Schematic representation and the cadaveric photograph of back of the trunk showing the angulation of latissimus dorsi muscle attached to the PTLF. In degrees on Right (R) and Left (L) sides at the spines of the T10, T11, T12, L1, L2, L3, L4 vertebrae.

Table I. Angulation of fascicle orientation of right and left middle and lower fibers of trapezius muscles at different vertebral level in mean degrees ± SD on Right (R) and Left (L) sides at the spines of the T1, T2, T4, T6, T8, T10, T12 vertebrae in degrees.

Vertebral level	Right side	Left side
T1	80.81 ± 2.40	80.83 ± 2.36
T2	90.34 ± 1.44	90.37 ± 1.43
T4	62.63 ± 2.53	62.63 ± 2.65
T6	51.37 ± 2.53	51.37 ± 2.66
T8	37.90 ± 0.97	37.93 ± 0.99
T10	20.58 ± 1.56	20.58 ± 1.57
T12	13.47 ± 1.18	13.47 ± 1.18

Table II. Angulation of fascicle orientation of right and left Latissimus dorsi muscles attached to the PTLF at different vertebral level in degrees.

Vertebral level	Right side	Left side
T10	122.71 ± 2.31	122.70 ± 2.31
T11	130.67 ± 1.55	130.67 ± 1.43
T12	157.67 ± 2.91	157.67 ± 2.91
L1	108.97 ± 2.53	108.97 ± 2.53
L2	93.95 ± 3.72	93.95 ± 3.72
L3	91.05 ± 1.15	91.05 ± 1.15
L4	85.87 ± 3.13	85.87 ± 3.13

Mean ± SD distance in degrees on Right (R) and Left (L) sides at the spines of the T10, T11, T12, L1, L2, L3, L4 vertebrae in degrees.

muscle with respect to PTLF was 168.95° ± 8.40° and 159.25° ± 12.27° on the right side and 169.02° ± 7.89° and 163.75° ± 11.10° on left side. At S1, S2, and S3 levels the angulation was around 90.06° ± 3.96° on right side 90.23° ± 3.61° on left side. There was no significant difference in the angulation on right gluteus maximus muscle compared to the left.

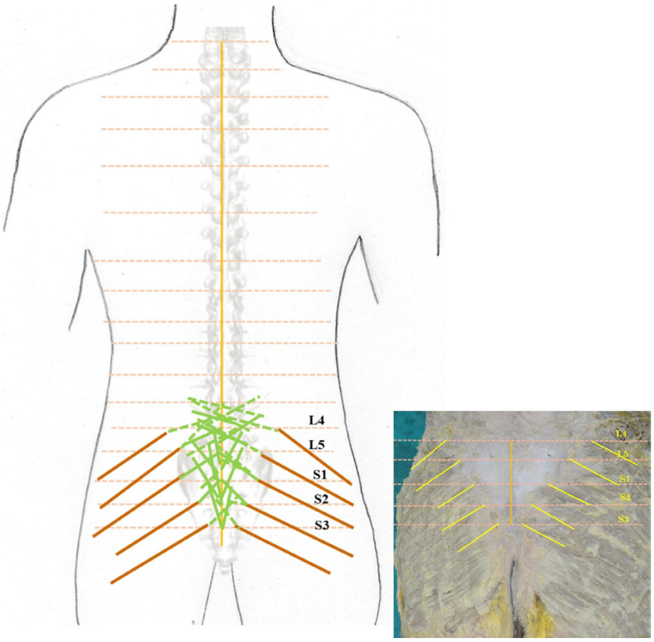

Figure 3. Schematic representation and the cadaveric photograph of back of the trunk showing the angulation of gluteus maximus muscles attached to the PTLF in degrees on Right (R) and Left (L) sides at the spines of the L4, L5, S1, S2, S3 vertebrae.

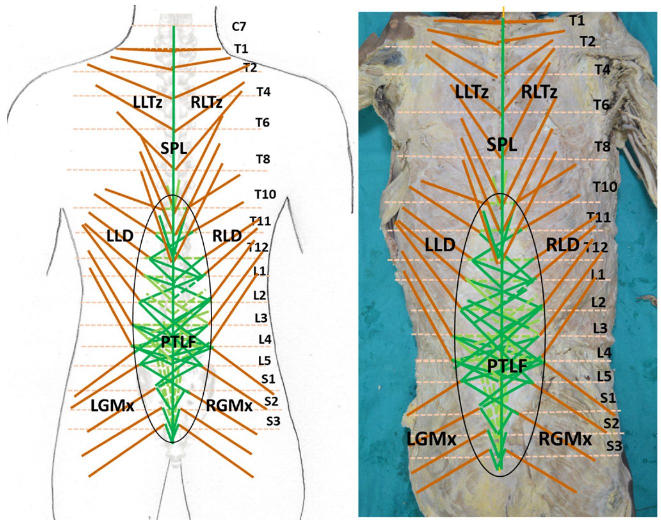

Figure 4. Schematic representation and the cadaveric photograph of back of the trunk showing the PTLF (oval encircled area) and supraspinous ligament and the superficial muscles attached to it. It also shows the fiber direction of the fascia and muscles.

LGMx: left gluteus maximus; RGMx: right gluteus maximus; LLD: left latissimus dorsi; RLD: right latissimus dorsi; LLTz: left lower trapezius; RLTz: right lower trapezius.

Table III. Angulation of fascicle orientation of right and left Gluteus maximus muscles attached to the PTLF at different vertebral level in degrees.

Vertebral level	Right side	Left side
L4	168.95 ± 8.40	169.02 ± 7.89
L5	159.25 ± 12.27	163.75 ± 11.10
S1	93.60 ± 5.71	94.35 ± 5.09
S2	91.05 ± 1.15	91.05 ± 1.15
S3	85.55 ± 5.02	85.30 ± 4.61

Following data were the mean ± SD distance in degrees on Right (R) and Left (L) sides at the spines of the L4, L5, S1, S2, S3 vertebrae in degrees.

DISCUSSION

Muscle fiber orientation (MFO) is an important parameter related to musculoskeletal functions (7). Present study evaluates the direction of muscles fascicles of superficial back muscles attached to PTLF and interspinous ligaments and we found that the direction and angulation of muscle fascicle differs for each muscle at different vertebral levels, but there was no significant difference between right and left side. It was interesting to note that where there is overlapping attachments of the muscles to PTLF, the fascicles of the upper muscle attach with acute angle and those of the lower muscles attach with more widened angles. Muscle fascicle angulation to PTLF was found more at the most movable part of the spine compared to the less movable areas. It was fascinating to note that across the 40 different male cadavers, the angulation of fascicles of each muscle seemed more or less similar, indicated by less SD of the calculated mean. In myofascial research, the alignment of muscle fibers and aponeuroses is often calculated first and then represented as basis for the assessment of muscle fiber length during morphological studies of skeletal muscles (8). Reasonable changes in the expected muscle line-of-action could significantly alter the extent of expected muscle forces. Most of the literature offer reports of the structures without precise data of fiber length, cross-sectional areas, line of action, forces, *etc.* To understand the momentum or line of pull of the muscle as a whole and the force generated and transferred across the myofascial linkage, we need better calculations of the muscle fiber attachments to the vertebrae, and more precise data of its line of pull (9). These data should provide novel insights into the ability of the superficial back muscles to generate force all over the spine, hip and shoulder ranges of motion. In addition, these findings should provide an improved understanding of the spine shoulder and hip positions at which the force-generating capacity of these muscles can become exposed, and therefore how this may affect its spine-stabilizing ability (10).

The PTLF plays an important role in the biomechanics of the vertebral column and thus it could be a source of low back pain. Attachment, collagen fiber direction, size and biomechanical properties of the PTLF have been well documented (11, 12). However, questions remain about the attachment of the PTLF in relation to adjoining muscles in the lumbosacral region. Moreover, quantitative data in relation to the muscle fascicle direction have rarely been examined. Thus far, the internal design of muscles has largely been overlooked, although it is well known that parameters such as pennation angles or the lengths of muscle fascicles, as well as the proportions of fleshy to tendinous fascicle parts have a major impact on the contraction behavior of a muscle (13). The direction of muscle fibers and pull of a muscle is crucial for a muscle's force exertion because the fascicles transmit force to the tendon and/or bone at different angles. Our results provide a database, which aims at refining biomechanical models of the human trunk (14).

Compared with limb muscles, the superficial back musculature is somewhat intricate encompassing fibre bundles of various lengths and orientations. Probably linked to this, how to train these architecturally different muscles has been under debate for decades (14). With the detailed description of fascicle orientation of these muscles added by our study, we hope the muscle training for body builders and sports personal may become more meaningful and effective. Knowledge of comprehension of human spine biomechanics applied to the workstation such as dentistry, should make it possible to modify practitioners' and equipment designers' habits. Therefore, professionals may objectively decrease their musculoskeletal strain of the back, while improving their efficiency (15).

This data will surely help physiotherapists and surgeons to get a surface anatomy picture of the superficial back muscles with detailed description of angulation of its fibers. Trapezius, latissimus dorsi, gluteus maximus and PTLF are common source of myofascial trigger points and thus common sites of myofascial pain. Hence, this data will help the manual therapists to release the myofascial trigger points with proper surface anatomical knowledge of the superficial back muscles. The thoracolumbar fascia (TLF), which gives attachment to many muscles and connective tissue has been a major concern for physical therapists since it is the likely main source of lower back pain (14, 15). Occupational trapezius myalgia is a common musculoskeletal disorder in office workers. Prolonged low-level muscle activity during office work may lead to morphological changes in the muscle tissue, causing pain and fatigue (16).

Limitations of the study

This is a cadaveric study carried out using forty embalmed human cadavers of various age. We are not sure whether the formalin fixation has got any effect on the angular orientation of muscle fibers with respect to the fascia. We would recommend the similar study on freshly dissected cadavers in future to record the muscle fiber angulation. The direction of muscle fibers in relation to the fascia need to be compared with electrophysiological properties of the same in living human to understand the anatomical and biomechanical factors causing the direction of force generated between the myofascial linkages.

CONCLUSIONS

This is the first of its kind of a study to contribute a database for the muscle fascicle direction and angulation of the superficial muscles of the back in relation to PTLF. We hope this data on myofascial continuity and orientation of muscle fascicle between the PTLF and the superficial back muscles will give insight to the synchronization between them. Direction of muscle fascicles attached to PTLF will help the manual therapists for better understanding to palpate the myofascial trigger points in those muscles and provide appropriate treatment. The knowledge of detailed architecture of the superficial back muscles will give more light to the individual muscle training process. As chronic back pain is a common complaint around the world, the information gathered in this study could be useful in understanding the kinematics and kinetics of the muscles involved in movements, and the data gathered here could be very useful for researchers in this field.

FUNDINGS

None.

DATA AVAILABILITY

Data can be accessed from repository link provided: https://learnermanipal-my.sharepoint.com/:x:/g/

personal/sapna_marpalli_manipal_edu/ESwyyg2fjZ1DnMHeIceO_KoBE1e5emxtZCmPANLTN8VfBw?e=BCyJTV.

CONTRIBUTIONS

SM: EMG recordings taken, draft preparation. MKGR, PV, BMG: data analysis and draft. BMG: conceptualization, monitoring of procedures.

ACKNOWLEDGEMENTS

We would like to acknowledge Manipal Academy of Higher Education, Manipal for providing lab facility for this study.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

REFERENCES

1. Barker PJ, Briggs CA. Attachments of the posterior layer of lumbar fascia. Spine (Phila Pa 1976) 1999;24(17):1757-64.
2. Carla S, Veronica M, Andrea P, Fabrice D, De Caro R. The fascia: The forgotten structure. Ital J Anat Embryol 2011;116(3):127-38. Available at: https://pubmed.ncbi.nlm.nih.gov/22852442/
3. Cao L, Wang Y, Hao D, et al. Effects of Force Load, Muscle Fatigue, and Magnetic Stimulation on Surface Electromyography during Side Arm Lateral Raise Task: A Preliminary Study with Healthy Subjects. Biomed Res Int 2017;2017:8943850.
4. Ourieff J, Scheckel B, Agarwal A. Anatomy, Back, Trapezius. 2021. In: StatPearls. Treasure Island (FL): StatPearls Publishing, 2022.
5. Prabhu LV, Pai MM, Rao YL, Murlimanju BV, Vadgaonkar R. Female cadaveric study of neurovascular pedicle in latissimus dorsi muscle flap. Muscles Ligaments Tendons J 2020;10(4):633-9.
6. Cunningham DJ, Robinson A. Cunningham's manual of practical anatomy. London: Humphrey Milford, Oxford University Press, 1920.
7. Ling S, Chen B, Zhou Y, et al. An efficient framework for estimation of muscle fiber orientation using ultrasonography. Biomed Eng Online 2013;12:98.
8. Kumagai K, Abe T, Brechue WF, Ryushi T, Takano S, Mizuno M. Sprint performance is related to muscle fascicle length in male 100-m sprinters. J Appl Physiol (1985) 2000;88(3):811-6.
9. Hansen L, de Zee M, Rasmussen J, Andersen TB, Wong C, Simonsen EB. Anatomy and biomechanics of the back muscles in the lumbar spine with reference to biomechanical modeling. Spine (Phila Pa 1976) 2006;31(17):1888-99.
10. Gerling ME, Brown SH. Architectural analysis and predicted functional capability of the human latissimus dorsi muscle. J Anat 2013;223(2):112-22.
11. Purslow PP. The Structure and Role of Intramuscular Connective Tissue in Muscle Function. Front Physiol 2020;11:495.
12. Marpalli S, Mohandas Rao KG, Venkatesan P, George BM. The morphological and microscopical characteristics of posterior layer of human thoracolumbar fascia; A potential source of low back pain. Morphologie 2021;105(351):308-15.
13. Creze M, Soubeyrand M, Nyangoh Timoh K, Gagey O. Organization of the fascia and aponeurosis in the lumbar paraspinal compartment. Surg Radiol Anat 2018;40(11):1231-42.
14. Stark H, Fröber R, Schilling N. Intramuscular architecture of the autochthonous back muscles in humans. J Anat 2013;222(2):214-22.
15. Blanc D, Farre P, Hamel O. Variability of musculoskeletal strain on dentists: an electromyographic and goniometric study. Int J Occup Saf Ergon 2014;20(2):295-307.