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Determination of the Body Segmental Muscle Mass Asymmetry among Boxers in Manipur: A Cross-Sectional Study

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Abstract: ***Background**: Boxing is a combat sport which requires repetitive bilateral upper-limb activity, with the lead and rear limbs performing distinct functional roles. These sport-specific demands may contribute to segmental muscle asymmetry, yet data among Indian boxers remain limited. **Objective**: To determine the body segmental muscle mass asymmetry among boxers in Manipur. **Study Design**: Cross-Sectional Study. **Methods**: A cross-sectional study was conducted among 47 elite boxers aged 18–35 years training at the Sports Authority of India (SAI) Training Centre, Imphal. Segmental skeletal muscle mass was assessed using bioelectrical impedance analysis (BIA). Upper- and lower-limb muscle asymmetry as well as upper-to-lower body asymmetry were determined. Data were analysed using descriptive statistics, chi-square test, and independent t-test. **Results**: Upper-limb muscle asymmetry was observed in 44.7% of participants, followed by upper-to-lower body asymmetry (29.8%) and lower-limb asymmetry (19.1%). The mean upper- and lower-limb muscle asymmetry percentages were 6.1 ± 2.4% and 3.2 ± 1.6%, respectively. No significant associations were found between upper-limb muscle asymmetry and gender ($p = 0.502$) or dominant punching hand ($p = 0.088$). **Conclusion**: Upper-limb muscle asymmetry was the predominant pattern among elite boxers. These findings provide baseline reference data for elite Indian boxers and support the use of segmental BIA for routine athlete monitoring and individualized training.***

Keywords: Boxing, Segmental muscle asymmetry, Bioelectrical impedance analysis, Sports Authority of India

1. Introduction

Boxing is one of the most physically demanding, high-intensity Olympic combat sports which requires precise integration of strength, speed, power, coordination, agility, and neuromuscular control to deliver effective punches while maintaining defensive stability throughout the competition.[1,2] Successful punching depends on the efficient transfer of force through the kinetic chain which begins in the lower limbs, progresses through the pelvis and trunk, and ultimately reaches the upper extremities.[2] This coordinated sequence enables maximal punch force generation while preserving postural balance and movement efficiency. Execution of repeated unilateral punching techniques over many years of training exposes athletes to chronic asymmetric mechanical loading thereby resulting in sport-specific musculoskeletal adaptations influencing skeletal muscle distribution, athletic performance, and injury susceptibility.[1]

Although human body is anatomically characterized by bilateral symmetry, functional limb dominance leads to physiological differences in muscle size, strength, and neuromuscular control between the dominant and non-dominant sides.[4,6] Such asymmetry develops naturally through preferential limb use during daily activities; however, it becomes substantially more pronounced in athletes who are participating in unilateral or asymmetrical sports. These repetitive sport-specific loading promote differential muscle hypertrophy and neuromuscular adaptations and so, can produce measurable variations in segmental muscle mass between corresponding body regions.[5,7] While moderate asymmetry may represent a beneficial adaptation enhancing the sport-specific performance, excessive asymmetry may compromise movement efficiency disturbing the biomechanical alignment, and increase the mechanical stress across muscles, tendons, ligaments, and joints.[5,9]

In recent years, inter-limb asymmetry has emerged as an important area of investigation in Sports Medicine because of its potential implications for both performance optimization and injury prevention. Excessive asymmetry has been observed to be associated with altered force transmission through the kinetic chain, impaired balance, reduced neuromuscular coordination, and compensatory movement strategies which ultimately result in increased cumulative tissue loading.[9,10,11] Systematic reviews have further demonstrated associations of greater inter-limb asymmetry with poorer performance in sprinting, jumping, change-of-direction tasks, and other functional activities. Not only these, athletes with marked asymmetry may also have an increased risk of overuse injuries and recurrent musculoskeletal injuries.[10,11,12] Consequently, early identification of clinically relevant asymmetry has become an important component of athlete screening, rehabilitation, and return-to-sport decision-making.

Therefore, accurate assessment of skeletal muscle distribution is essential for monitoring athletic adaptations and identifying athletes who may benefit from individualized corrective interventions. Bioelectrical impedance analysis (BIA) has emerged as a practical, non-invasive, rapid, and cost-effective technique for evaluation of body composition by measuring electrical conductivity of tissues.[3] Compared with dual-energy X-ray absorptiometry (DXA), computed tomography, or magnetic resonance imaging, segmental BIA offers excellent practicality for field-based assessments because it is portable, requires minimal operator training, involves no radiation exposure, and provides independent estimates of skeletal muscle mass for each limb within a short period.[3,13] These are the characteristics which make segmental BIA particularly suitable for - routine athlete monitoring, longitudinal evaluation of training adaptations, and screening for muscle asymmetry in Sports Medicine settings.

Previous studies have demonstrated that sport-specific training produces characteristic patterns of muscle distribution across different athletic populations. Yamada et al. reported significant inter-sport variability in segmental muscle volume among athletes who are participating in different ball sports, highlighting the influence of discipline-specific movement demands on muscular development.[8] Similarly, Lijewski et al. demonstrated significant bilateral differences in segmental muscle mass among competitive handball players using segmental BIA which indicates the production of measurable muscular asymmetry by repetitive unilateral sporting activities.[14] Stachoń et al. further reported distinct asymmetry profiles across athletes from different sports, suggesting that repetitive asymmetric loading contributes to sport-specific adaptations in skeletal muscle distribution.[15] Likewise, Hart et al. observed a progressively greater inter-limb asymmetry with increasing training exposure among football athletes, whereas Helme et al. reported that greater asymmetry may be associated with a higher incidence of sports-related injuries.[12,16] It emphasizes the clinical relevance for assessment of asymmetry in athletic populations.

Although the available literature clearly demonstrates the presence of muscular asymmetry in athletes, most previous studies have been focussing on football, handball, volleyball, tennis, etc. Evidence regarding competitive boxing remains comparatively limited, despite the unique biomechanical characteristics of boxing. Unlike many other sports, boxing requires repeated punching combined with coordinated lower-limb force production, trunk rotation, weight transfer, and stance-specific stabilization throughout the kinetic chain.[2] Consequently, the pattern of skeletal muscle adaptation observed in boxers cannot be assumed to mirror that of athletes participating in other sports, underscoring the need for sport-specific investigation.

Furthermore, most published studies have evaluated strength asymmetry, functional asymmetry, or performance-based asymmetry, whereas comparatively few have specifically examined segmental skeletal muscle mass asymmetry using BIA. This quantification of muscle mass asymmetry will provide a structural information that complements functional performance assessments and may facilitate earlier identification of athletes at risk of developing biomechanical inefficiencies or overuse injuries.[3,9,13] Despite the growing international interest in athlete asymmetry, normative data describing segmental skeletal muscle mass distribution among Indian competitive boxers are virtually non-existent.

To the best of our knowledge, no published Indian study has simultaneously evaluated upper-limb muscle asymmetry, lower-limb muscle asymmetry, and upper-to-lower body muscle distribution using segmental bioelectrical impedance analysis in elite boxers. Establishing baseline data from Manipur is particularly important because the state has consistently produced some of India's most successful national and international boxers, making it an appropriate setting for investigating this boxing-specific musculoskeletal adaptations.

Therefore, our study was undertaken to determine the prevalence and magnitude of body segmental muscle mass asymmetry among elite boxers in Manipur using segmental BIA. By establishing regional normative data for upper-limb, lower-limb, and upper-to-lower body muscle distribution, this study aims to improve understanding of boxing-specific muscular adaptations and provide evidence that may support individualized strength and conditioning programmes, injury prevention strategies, rehabilitation planning, and informed return-to-sport decisions in competitive boxers.

Therefore, the present study was undertaken to determine the prevalence and magnitude of body segmental muscle mass asymmetry among elite boxers in Manipur using segmental BIA. By establishing normative reference data for upper-limb, lower-limb, and upper-to-lower body muscle distribution, this study seeks to enhance understanding of boxing-specific muscular adaptations. The findings may facilitate early identification of clinically relevant asymmetry and provide an evidence base for individualized strength and conditioning programmes, injury prevention strategies, rehabilitation planning, and return-to-sport decision-making in competitive boxers.

2. Materials and Methods

Study Design: Cross Sectional study

Study Setting: Department of Sports Medicine, Regional Institute of Medical Sciences, Imphal. In a year, around 15000 patients are seen in the outpatient department

Duration of Study: 1 year starting from July 2025

Study tools: InBody 370S Body Composition Analyzer (InBody Co., Ltd., Seoul, South Korea, 2020) and Stadiometer

Study population: The study population comprised elite boxers undergoing regular training at the Sports Authority of India (SAI) Centre, Imphal, Manipur. Participants were recruited by convenience sampling.
The calculated sample size was 47 participants, based on the prevalence reported by Lijewski et al. (2021), assuming a 95% confidence level, an absolute precision of 2% and 7 % of standard deviation.[15]

Inclusion criteria
- Boxers aged 18–35 years
- Minimum of one year of continuous boxing training
- Actively participating in training or competition at the time of recruitment
- Free from any current medical illness or musculoskeletal injury
- Willing to provide written informed consent

Exclusion criteria
- A history of upper- or lower-limb injury or surgery within the preceding six months
- Any acute illness at the time of assessment

Data collection:
Participation was voluntary, and the participants were provided a thorough explanation of the objectives, methods, and ethical considerations of this study. A written informed consent was obtained from all the participants included in the study.

Data collection was carried out during the morning hours with participants in a fasting state to minimize the influence of hydration status on bioelectrical impedance measurements.

The participants' demographic information was prospectively recorded, including age, sex, and dominant punching hand. Anthropometric measurements, including height and body weight, were obtained, and body mass index (BMI) was calculated. Total skeletal muscle mass and segmental skeletal muscle mass of the upper and lower limbs were measured using the InBody 370S Body Composition Analyzer.

Further, the following outcome measures were derived:
1) Upper-limb muscle asymmetry (%)
2) Lower-limb muscle asymmetry (%)
3) Upper-to-lower body muscle ratio

Upper- and lower-limb muscle asymmetry were calculated using the formula:

$$\text{Asymmetry (\%)} = \frac{(Right - Left)}{\frac{1}{2}(right + left)} \times 100$$

An asymmetry value of **≥5%** was considered indicative of clinically relevant upper- or lower-limb muscle asymmetry.

Upper-to-lower body muscle asymmetry was defined as a muscle ratio lying outside ±1 standard deviation of the study population mean. All collected data were checked for completeness and consistency before analysis.

Analysis
Data was collected and analyzed statistically using IBM SPSS version 26.0. Descriptive statistics like mean, frequency, percentage and standard deviation were used. The association between categorical variables was assessed using the Chi-square test, while differences in continuous variables were analyzed using the independent-samples t-test. A p-value <0.05 was considered statistically significant.

Ethical approval of the Research Ethics Board, RIMS, Imphal was taken for this clinical study.

3. Results

A total of 47 elite boxers were included in the study. The mean age was 19.6 ± 2.4 years, with a mean body mass index (BMI) of 22.8 ± 2.1 kg/m² and a mean total skeletal muscle mass of 31.2 ± 4.3 kg. Participants' demographic and anthropometric characteristics are presented in Table 1.

Table 1: Demographic and anthropometric characteristics of the participants (n = 47)

Variable	Mean ± SD
Age (years)	19.6 ± 2.4
Body mass index (kg/m²)	22.8 ± 2.1
Total skeletal muscle mass (kg)	31.2 ± 4.3

Gender distribution: Of the 47 participants, 38 (80.9%) were males and 9 (19.1%) were females (Figure 1).

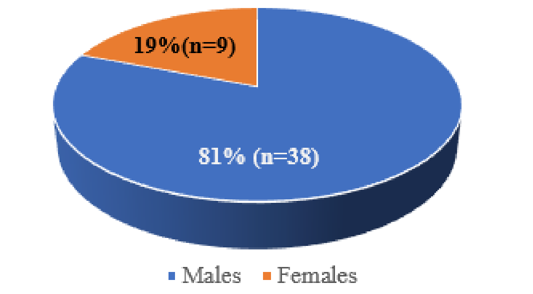

Figure 1: Gender distribution of the study participants

Dominant punching hand: The majority of participants were right-hand dominant (87.2%), while 12.8% were left-hand dominant (Figure 2).

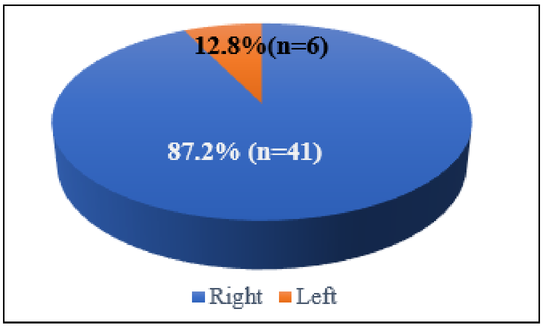

Figure 2: Distribution of dominant punching hand

Prevalence of segmental muscle mass asymmetry: Upper-limb muscle asymmetry was the most common finding and was observed in 21 (44.7%) participants. Lower-limb muscle asymmetry was identified in 9 (19.1%), while 14 (29.8%) participants demonstrated upper-to-lower body muscle asymmetry (Table 2).

Table 2: Prevalence of segmental muscle mass asymmetry

Type of asymmetry	Present n (%)	Absent n (%)
Upper limb muscle asymmetry	21 (44.7)	26 (55.3)
Lower limb muscle asymmetry	9 (19.1)	38 (80.9)
Upper-lower body muscle asymmetry	14 (29.8)	33 (70.2)

Magnitude of muscle asymmetry: The mean upper-limb muscle asymmetry was 6.1 ± 2.4%, whereas the mean lower-limb muscle asymmetry was 3.2 ± 1.6%. The mean upper-to-lower body muscle ratio was 0.35 ± 0.05, indicating the relative distribution of skeletal muscle mass between the upper and lower body segments (Table 3).

Table 3: Magnitude of muscle asymmetry and upper-lower body muscle ratio

Variable	Mean ± SD
Upper limb muscle asymmetry (%)	6.1 ± 2.4
Lower limb muscle asymmetry (%)	3.2 ± 1.6
Upper-lower body muscle ratio	0.35 ± 0.05

Association between gender and upper-limb muscle asymmetry: Upper-limb muscle asymmetry was observed more frequently among male boxers (47.4%) than female boxers (33.3%). However, the association between gender and upper-limb muscle asymmetry was not statistically significant (χ^2 test, p = 0.502) (Table 4).

Table 4: Association between gender and upper-limb muscle asymmetry (# = χ^2 test)

Gender	Asymmetry present n (%)	Asymmetry absent n (%)	p-value#
Male (n = 38)	18 (47.4)	20 (52.6)	0.502
Female (n = 9)	3 (33.3)	6 (66.7)	

Comparison of upper-limb muscle asymmetry according to dominant punching hand: Right-hand dominant boxers demonstrated a higher mean upper-limb muscle asymmetry percentage (5.82 ± 2.31%) than left-hand dominant boxers (4.10 ± 1.95%). However, this difference was not statistically significant (independent-samples t-test, p = 0.088) (Table 5).

Table 5: Comparison of upper-limb muscle asymmetry according to dominant punching hand (* = Independent t-test)

Dominant hand	n	Mean ± SD (%)	p-value*
Right	41	5.82 ± 2.31	0.088
Left	6	4.10 ± 1.95	

4. Discussion

The present study evaluated body segmental muscle mass asymmetry among elite boxers using segmental BIA. The principal findings were that upper-limb muscle asymmetry was the most prevalent abnormality (44.7%), followed by upper-to-lower body muscle asymmetry (29.8%) and lower-limb muscle asymmetry (19.1%). Upper-limb asymmetry was more pronounced than lower-limb asymmetry, whereas no significant association was observed between muscle asymmetry and either gender or dominant punching hand. These findings suggest that long-term boxing-specific training predominantly influences upper-limb muscular development and produces characteristic patterns of segmental adaptation.

Upper-limb muscle asymmetry was the predominant finding and it is consistent with the biomechanical demands of boxing. Effective punching requires rapid sequential force transfer from the lower limbs through the trunk to the upper extremities which expose the upper limbs to repeated high-velocity loading and sport-specific muscular adaptation.[1,2] Similar findings have been reported by Lijewski et al., who demonstrated that there are significant bilateral differences in segmental muscle mass among competitive handball players using segmental BIA, highlighting the influence of repetitive unilateral sporting actions on muscle development.[14] Likewise, Stachoń et al. also observed discipline-specific asymmetry patterns among athletes participating in asymmetrical sports which emphasize contribution of chronic unilateral loading to side-to-side differences in muscle mass.[15] Therefore, the upper-limb asymmetry observed in the present study is likely to represent a physiological adaptation to the sport rather than a pathological imbalance.

Lower-limb muscle asymmetry was considerably less prevalent than upper-limb asymmetry. Although the lower extremities are essential for force generation, balance, and footwork, both limbs contribute continuously throughout training and competition. Unlike sports such as tennis or fencing, successful boxing performance depends on coordinated bilateral movement, with athletes repeatedly engaging both the lead and rear limbs during punching, defensive actions, weight transfer, and ring movement. This bilateral functional demand may partly explain the relatively symmetrical lower-limb muscle distribution and the absence of significant differences according to dominant punching hand. This interpretation is supported by Yamada et al., who reported that skeletal muscle distribution reflects the specific functional demands and movement characteristics of individual sports.[8]

The upper-to-lower body muscle ratio further illustrates the integrated muscular adaptations associated with boxing. Because successful performance depends on upper-body strength for punching and lower-body strength for force production, balance, and postural control, this ratio provides a useful indicator of whole-body muscle distribution beyond simple right-to-left comparisons. As normative data which describes upper-to-lower body muscle distribution in elite boxers remain scarce, the present findings contribute baseline reference values that may support future research to evaluate training adaptations, rehabilitation outcomes, and readiness of return-to-sport.

No statistically significant association was observed between upper-limb muscle asymmetry and either gender or dominant punching hand. Although asymmetry was numerically greater among male and right-hand dominant athletes, these differences did not reach statistical significance. It could be due to the relatively small number of female and left-hand dominant participants. Furthermore, Hart et al. and Bishop et al. have suggested that inter-limb asymmetry is influenced by cumulative training exposure, technical proficiency, and sport-specific loading rather than limb dominance alone.[10,16] Therefore, it is a better way to say that muscle asymmetry should be interpreted within the broader context of an athlete's training history instead of handedness as an isolated determinant.

From a clinical perspective, routine assessment of muscle asymmetry may enhance athlete monitoring and injury prevention. Bishop et al. demonstrated that excessive inter-limb asymmetry may impair sprinting, jumping, and change-of-direction performance, while Helme et al. reported that greater asymmetry is associated with an increased risk of musculoskeletal injury and recurrent injury episodes.[10,12] Although injury outcomes were not evaluated in the present study, the high prevalence of upper-limb asymmetry supports the incorporation of segmental BIA into preseason screening and periodic athlete evaluations. Early identification of athletes with marked asymmetry may facilitate individualized strength and conditioning programmes, targeted rehabilitation, and longitudinal monitoring of training adaptations.

The present study has several strengths. To the best of our knowledge, it is the first study from India to simultaneously evaluate upper-limb, lower-limb, and upper-to-lower body muscle asymmetry in elite boxers using segmental BIA. Participants were recruited from the Sports Authority of India (SAI) Training Centre, Imphal, one of India's premier high-performance boxing centres, which develops elite boxers from multiple states across the country. At the same time, the centre is located in Manipur, one of India's most successful boxing regions and home to numerous national and international medal-winning boxers. Consequently, the study provides baseline reference data from a nationally important training environment while demonstrating the practical applicability of segmental BIA in elite athlete monitoring.

This cross-sectional design limits causal inference, and recruitment from a single training centre with a relatively small sample may restrict the generalizability of the findings. Moreover, the absence of muscle strength, functional performance, and injury assessments prevented evaluation of the clinical relevance of the observed asymmetry. Future multicentre longitudinal studies are warranted to establish clinically meaningful thresholds and determine their association with athletic performance and injury risk.

Overall, the present study demonstrates that segmental muscle mass asymmetry is common among elite boxers, with upper-limb asymmetry representing the predominant pattern of sport-specific adaptation. These findings provide novel baseline reference data for elite Indian boxers and support the incorporation of segmental BIA into routine athlete screening and longitudinal monitoring. Such assessments may facilitate individualized training interventions aimed at optimizing performance while minimizing injury risk.

5. Conclusion

Upper-limb muscle asymmetry was the predominant pattern of muscle imbalance among elite boxers, while lower-limb asymmetry was less common. Segmental BIA offers a simple, non-invasive approach for identifying these adaptations and may support individualized athlete monitoring. This study provides baseline reference data for elite Indian boxers and establishes a foundation for future multicentre longitudinal research.

References

[1] Beattie K, Ruddock AD. Strength training practices in amateur and professional boxing. J Strength Cond Res. 2025;39(6):672-9.
[2] Dunn EC, Humberstone CE, Franchini E, Iredale KF, Blazevich AJ. Relationships between punch impact force and upper- and lower-body muscular strength and power in highly trained amateur boxers. J Strength Cond Res. 2022;36(4):1019-25.
[3] Quist JR, Isidor SD, Hvas CL, Iversen PR, Jødal L, Rud CL, et al. Bioelectrical impedance analysis for assessing body composition. Ugeskr Laeger. 2025;187(6): V04240287.
[4] Corballis MC. The evolution and genetics of cerebral asymmetry. Philos Trans R Soc Lond B Biol Sci. 2009;364(1519):867-79.
[5] Van Dongen S. Fluctuating asymmetry and developmental instability in evolutionary biology: past, present and future. J Evol Biol. 2006;19(6):1727-43.
[6] Raymond M, Pontier D. Is there geographical variation in human handedness? Laterality. 2004;9(1):35-51.
[7] Kanchan T, Mohan Kumar TS, Pradeep Kumar G, Yoganarasimha K. Skeletal asymmetry. J Forensic Leg Med. 2008;15(3):177-9.

[8] Yamada Y, Masuo Y, Nakamura E, Oda S. Inter-sport variability of muscle volume distribution identified by segmental bioelectrical impedance analysis in four ball sports. Open Access J Sports Med. 2013; 4: 97-108.
[9] Bishop C, Read P, Lake J, Chavda S, Turner A. Interlimb asymmetries: understanding how to calculate differences from bilateral and unilateral tests. Strength Cond J. 2018;40(4):1-6.
[10] Bishop C, Turner A, Read P. Effects of inter-limb asymmetries on physical and sports performance: a systematic review. J Sports Sci. 2018;36(10):1135-44.
[11] Maloney SJ. The relationship between asymmetry and athletic performance: a critical review. J Strength Cond Res. 2019;33(9):2579-93.
[12] Helme M, Tee J, Emmonds S, Low C. Does lower-limb asymmetry increase injury risk in sport? A systematic review. Phys Ther Sport. 2021; 49: 204-13.
[13] Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Gómez JM, et al. Bioelectrical impedance analysis—Part I: review of principles and methods. Clin Nutr. 2004;23(5):1226-43.
[14] Lijewski M, Burdukiewicz A, Pietraszewska J, Andrzejewska J, Stachoń A. Asymmetry of muscle mass distribution and grip strength in professional handball players. Int J Environ Res Public Health. 2021;18(4):1913.
[15] Stachoń A, Pietraszewska J, Burdukiewicz A. Diversity in body composition, segmental muscle mass distribution and isometric strength in team sports. Acta Bioeng Biomech. 2025;27(2):3-13.
[16] Hart NH, Nimphius S, Weber J, Spiteri T, Rantalainen T, Dobbin M, et al. Musculoskeletal asymmetry in football athletes: a product of limb function over time. Med Sci Sports Exerc. 2016;48(7):1379-87.