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The Surface Electromyographic Characteristics of Different Practice Methods of Chen-Style Tai Chi *Lanzhayi* Movement

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Abstract

This study examined the surface electromyographic characteristics of the Chen-style Tai Chi Lanzhayi movement across different practice methods to clarify its neuromuscular demands and inform scientific training. Nine experienced practitioners completed slow practice, rapid power practice, practical combat practice, and a 60-s standing exercise. Surface electromyographic signals from 16 muscles and synchronised video data were collected using a MEGWIN 6000 16-channel telemetry system. Root mean square (RMS) amplitude and integrated electromyography (iEMG) were analysed. Stage 3 of the three dynamic conditions was compared using repeated-measures analysis of variance, and activation sequence was examined descriptively in one expert participant. In stages 1 and 2, the left and right tibialis anterior muscles showed the highest RMS and iEMG values. In stage 3, RMS differed significantly among conditions and increased from slow practice to rapid power practice and practical combat practice, whereas total iEMG did not differ significantly. In the expert-case analysis, activation sequence varied across practice methods and did not follow a fixed foot-leg-waist-hand order. During the standing exercise, left-leg iEMG exceeded right-leg iEMG, whereas right-arm iEMG exceeded left-arm iEMG. Practice method influenced muscle activation intensity and coordination during Lanzhayi. Training that more closely approximates practical combat may be useful for developing combat-specific performance. The traditional principle that power begins in the feet, passes through the legs, is controlled by the waist, and manifests in the hands may guide whole-body coordination, but should not be interpreted as a fixed sequence of muscle activation. The observed left-right asymmetries require confirmation in larger samples.

Introduction

Tai Chi is a traditional Chinese practice that integrates martial techniques, artistic expression, and health-related exercise (Li, 2018). It is widely practised in China, with more than 50 million practitioners (Zhang, 2019). On 17 December 2020, UNESCO inscribed Tai Chi on the Representative List of the Intangible Cultural Heritage of Humanity (Xinhua News Agency, 2020. Tai Chi originated in Chenjiagou, Wen County, Henan Province, China, and the form associated with this region is known as Chen-style Tai Chi. As the practice evolved, it gave rise to the Yang, Wu (Hao), Wu, and Sun styles. Qi Jiguang described a movement resembling *Lanzhayi* in *Ji Xiao Xin Shu: Quan Jing* during the Ming dynasty, and the movement later became representative of Chen-style Tai Chi and other Tai Chi traditions. Tai Chi includes eight jin methods; *Lanzhayi* emphasises four primary methods: peng, lü, ji, and an.

Surface electromyography (sEMG) is widely used in sport, medicine, and exercise science to assess neuromuscular activity (Liu et al., 2022; Liang et al., 2023). It is a non-invasive technique commonly analysed in the time and frequency domains. Time-domain measures such as integrated electromyography (iEMG) and root mean square (RMS) amplitude can be used to examine muscle activation, contribution, and coordination during movement. Frequency-domain measures, including median frequency and mean power frequency, are commonly used to investigate muscle fatigue (Wang & Huang, 2019).

Electromyographic research on Tai Chi has a long history. Zhang and Huang (1989) quantitatively analysed sEMG during the first form of Chen-style Tai Chi and described general characteristics of muscle activity during practice. Wang and Yang (1996) compared the EMG of athletes practising different Tai Chi styles. Chan et al. (2003) analysed a Tai Chi master's push movement and reported that eccentric contractions of the lower-limb muscles may contribute to strengthening. Niu (2010) compared stage-specific sEMG characteristics of Tai Chi pushing-hands techniques among athletes of different skill levels. Zhu et al. (2014) combined three-dimensional motion analysis, force measurement, and telemetry sEMG to examine power generation during Chen-style Tai Chi Yanshou Hongchui. Yu et al. (2022) investigated pre-activation and co-contraction of knee and ankle muscles during brush-knee twist-step and normal walking in long-term practitioners to explore neuromuscular strategies relevant to fall prevention. More recently, Huang et al. (2024) combined three-dimensional motion capture, force-platform data, and sEMG to examine relationships among biomechanics, muscle activation, and stability during the 143D balance movement in competitive Tai Chi. Together, these studies show that sEMG can provide useful evidence about muscle recruitment and motor control in specific Tai Chi techniques.

Existing EMG studies of Tai Chi have mainly analysed muscle activity during practice, compared the same movement across skill levels, or examined health-related effects. However, little research has compared the neuromuscular characteristics of different practice methods applied to the same Tai Chi movement. Therefore, this study used a MEGWIN 6000 16-channel telemetry sEMG system and a Sony DCR-HC90 video camera to collect muscle-activation and kinematic data from nine practitioners performing Chen-style Tai Chi *Lanzhayi* under different practice conditions. The aim was to clarify how practice method influences muscle activation, strengthen the scientific basis of martial arts teaching and training, and provide practical guidance for Tai Chi training.

Methods

Study participants

Nine participants (seven men and two women) took part in the study. Their mean age was 29.44 ± 6.66 years, mean height was 170.44 ± 6.65 cm, and mean body mass was 68.77 ± 7.91 kg. The sample comprised one professor who was also a Tai Chi expert, three champions of major domestic Tai Chi tournaments, and five recreational practitioners. All participants were proficient in the selected Chen-style Tai Chi *Lanzhayi* practice methods.

Ethics, equipment, and setting

The study was reviewed by an expert panel and approved by the Ethics Committee of Sport Science at Beijing Sport University. All participants provided informed consent and were told that they could withdraw at any time without penalty. To reduce injury risk, practical combat practice was conducted under professional supervision, and participants were familiar with safe-falling techniques. Testing took place in the hall of the Sport Science Research Centre at Beijing Sport University (Figure 1). A MEGWIN 6000 16-channel telemetry sEMG system and a Sony DCR-HC90 video camera were used. Room temperature was maintained at approximately 20 °C. The same professional staff prepared the participants, operated the equipment, and recorded all trials. Video and photographic data were stored securely and accessed only by the research team; identifying features in submitted figures were masked.

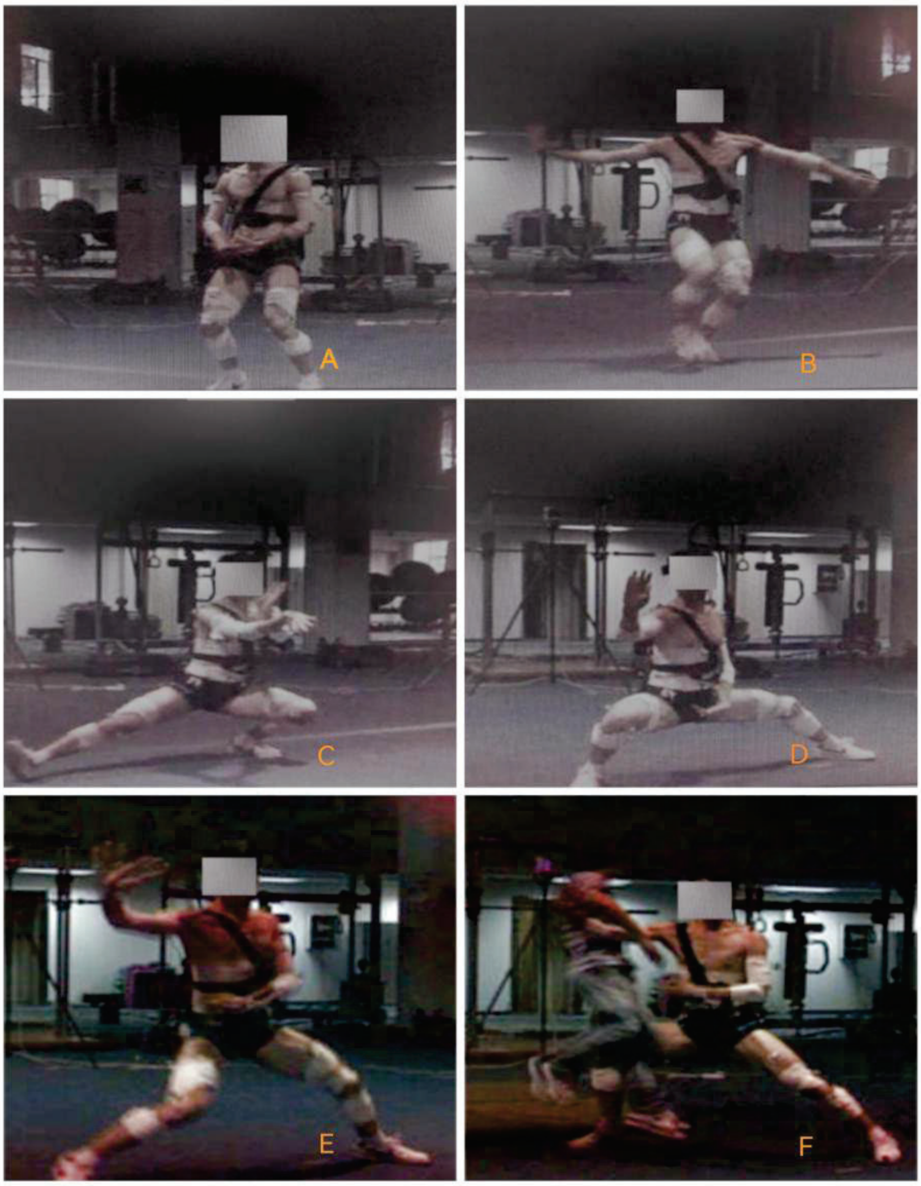

Figure 1. Experimental site layout and division of action stages

Movement definition and stage division

The *Lanzhayi* movement was divided into three stages according to the requirements and offensive and defensive meanings of the Chen-style Tai Chi competition routine. Stage 1 (A-B), 'receiving the opponent's attacking force,' extended from the end of Jingangdaozhui until the right foot began to leave the ground. Stage 2 (B-C), 'leading in the opponent and disrupting balance,' extended from right-foot lift-off until right-foot contact. Stage 3 (C-D), 'throwing the opponent,' extended from right-foot contact to completion of *Lanzhayi* (China Martial Arts Research Institute, 1999).

The four practice conditions were defined as follows:

(1) Slow practice: the movement was performed according to the standard Chen-style Tai Chi competition routine.

(2) Rapid power practice: stages 1 and 2 were performed slowly according to the competition routine, and rapid force was generated from point C during stage 3.

(3) Practical combat practice: stages 1 and 2 were performed slowly according to the competition routine. From point C, the participant prepared to throw a partner and executed the throw during stage 3. The same partner was thrown in all trials.

(4) Standing exercise: participants maintained the fixed *Lanzhayi* posture at point D for 1 min.

sEMG recording and data analysis

Tai Chi force generation depends on whole-body coordination. Based on the movement characteristics and combat applications of *Lanzhayi*, together with the recommendations of Chinese martial arts and exercise-physiology experts, 16 muscles of the lower limbs, trunk, and upper limbs were selected for testing (Table 1). Electrode locations were determined from the anatomical position of each muscle and established recommendations for surface-electrode placement (Hermens et al., 2000).

Table 1. List of selected muscles

Position	Left side muscles and number	Right side muscles and number
Lower limbs	1. Left tibialis anterior muscle	9. Right tibialis anterior muscle
	2. Left gastrocnemius muscle	10. Right gastrocnemius muscle
	3. Left rectus femoris muscle	11. Right rectus femoris muscle
Trunk	4. Left external abdominal oblique muscle	12. Right external abdominal oblique muscle
	5. Left latissimus dorsi muscle	13. Right latissimus dorsi muscle
Upper limbs	6. Left deltoid muscle	14. Right deltoid muscle
	7. Left triceps brachii muscle	15. Right triceps brachii muscle
	8. Left brachioradialis muscle	16. Right brachioradialis muscle

Before electrode placement, hair was removed with a razor, the skin was gently abraded with fine sandpaper, and the site was cleaned with 75% alcohol to remove oil. After the alcohol had evaporated, electrode paste was applied. Electrodes were positioned over the most prominent part of each muscle belly, with a centre-to-centre distance of 2 cm, and aligned with the direction of the muscle fibres.

The sEMG system sampled at 1,000 Hz. Each dynamic practice condition was performed three times, with a 5-min rest between trials. The MEGWIN 6000 16-software was used with its default settings to process the signals, segment the data using synchronised video, and export values for each movement segment. Because of resource limitations, sEMG amplitudes were not normalised to maximal voluntary contraction (MVC). Data were analysed in IBM SPSS Statistics, version 22.0. One-way repeated-measures analysis of variance was used to compare the three practice methods because all participants completed all conditions. Total RMS and total iEMG were the primary outcomes, and muscle-specific analyses were treated as exploratory. For post hoc pairwise comparisons, the least significant difference (LSD) test was used when the homogeneity-of-variance assumption was met; otherwise, Tamhane's T2 test was used. Activation sequence in participant 1, the Tai Chi expert, was examined using the percentage-peak method. An EMG amplitude greater than 20% of that muscle's maximum amplitude marked the onset of activation; values below this threshold were treated as inactive. Activation time was expressed as a percentage of total movement duration. Because the sequence analysis was based on one expert, it was interpreted as an illustrative case rather than a group-level finding.

Study hypotheses

The hypotheses were as follows:

(1) Muscle sEMG characteristics differ among slow practice, rapid power practice, and practical combat practice within the same movement stage. Specifically, RMS and iEMG values were expected to differ across the three conditions.

(2) During stage 3, muscle activation follows the traditional whole-body sequence in which power begins in the feet, passes through the legs and waist, and is expressed through the hands. Accordingly, activation was expected to proceed from lower-limb muscles to trunk muscles and then upper-limb muscles.

(3) During the standing exercise, iEMG is greater in the right, solid leg than in the left, empty leg.

Results

Stages 1 and 2 of the *Lanzhayi* movement

RMS amplitude reflects the magnitude of the sEMG signal and is commonly used as an indicator of motor-unit recruitment and muscle activation intensity. RMS generally increases as muscle force increases (Luo et al., 2017).

From an attack-and-defence perspective, stage 1 represents 'receiving the opponent's attacking force,' whereas stage 2 represents 'leading in the opponent and disrupting balance.' These stages prepare for force generation in *Lanzhayi*. RMS values for each muscle are presented in Table 2.

In stage 1, the left and right tibialis anterior muscles had the two highest RMS values, whereas the right external oblique had the lowest value. In stage 2, the left and right tibialis anterior again had the highest RMS values, and the right gastrocnemius had the lowest value (Table 2).

iEMG reflects accumulated muscle activity over a specified period and can provide an estimate of the total muscular work required for a movement (Sun et al., 2010). A muscle's contribution rate is its iEMG expressed as a percentage of the summed iEMG of all measured

muscles, indicating its relative contribution to the movement (Song et al., 2016). RMS therefore reflects activation intensity, whereas iEMG reflects accumulated activity (Xu et al., 2022).
To examine the contribution of each muscle during stages 1 and 2, iEMG and contribution rates were calculated for individual muscles, body regions, and left and right sides (Tables 3 and 4).

The left and right tibialis anterior muscles had the highest iEMG values in both stages 1 and 2 (Table 3). During stage 1, body weight shifted from left to right and back to left. The high activation of both tibialis anterior muscles therefore appears to reflect their role in controlling weight transfer while the knees remained flexed.

During stage 2, the combined iEMG of the three measured muscles in the left and right legs was distributed at approximately 6:4 (Table 4). Thus, although the right leg was considered the empty leg during the step-opening phase, it continued to generate force, indicating active muscular control of the stepping limb.

Table 2. RMS (μV) for subjects in stages 1 and 2

Muscles	Stage 1	Stage 2
LTAM	149.56±60.81	272.11±104.97
LGM	58.22±3.19	94.44±21.81
LRFM	101.00±60.69	172.33±65.40
LEAOM	66.22±9.15	76.89±11.05
LLDM	75.56±18.28	83.11±9.66
LDM	86.78±27.86	123.00±59.45
LTBM	65.78±9.93	80.44±19.65
LBM	86.89±45.50	115.11±74.75
RTAM	120.67±56.38	223.33±116.92
RGM	31.56±21.44	52.78±40.62
RRFM	48.56±31.96	84.11±25.22
REAOM	22.56±11.83	82.56±45.32
RLDM	65.00±12.41	82.78±14.24
RDM	82.44±16.52	116.78±31.43
RTBM	72.89±18.15	97.33±24.53
RBM	101.33±28.62	133.44±67.26

Table 3. iEMG (μV·s) and contribution rates (%) of subjects in stages 1 and 2

Muscles	Stage 1	Contribution rate	Stage 2	Contribution rate
LTAM	470.11 ± 167.96	11.62	351.33 ± 176.63	14.78
LGM	206.11 ± 112.78	5.09	119.44 ± 50.44	5.02
LRFM	308.44 ± 117.55	7.62	210.11 ± 95.67	8.84
LEAOM	231.11 ± 117.23	5.71	94.22 ± 26.10	3.96
LLDM	252.22 ± 103.69	6.23	101.22 ± 27.70	4.26

LDM	289.78 ± 125.64	7.16	154.00 ± 91.03	6.48
LTBM	226.67 ± 107.85	5.60	100.22 ± 40.07	4.22
LBM	294.22 ± 203.99	7.27	154.89 ± 137.94	6.52
RTAM	377.44 ± 145.65	9.33	282.00 ± 168.18	11.86
RGM	97.89 ± 67.92	2.42	62.89 ± 62.10	2.65
RRFM	150.67 ± 69.41	3.72	104.11 ± 38.74	4.38
REAOM	76.22 ± 44.29	1.88	114.00 ± 90.73	4.80
RLDM	220.67 ± 99.99	5.45	99.56 ± 27.88	4.19
RDM	275.44 ± 104.41	6.81	148.33 ± 70.40	6.24
RTBM	244.56 ± 103.63	6.04	121.56 ± 45.95	5.11
RBM	325.22 ± 90.21	8.04	159.11 ± 80.06	6.69

Table 4. Comparison of the contribution rates (%) of subjects in stages 1 and 2

Stages	Position	Left side	Right side
Stage 1	Lower limbs	61.13	38.87
Stage 2		60.26	39.74
Stage 1	Trunk	61.95	38.05
Stage 2		47.78	52.22
Stage 1	Upper limbs	48.96	51.04
Stage 2		48.81	51.19
Stage 1	All muscles	56.31	43.69
Stage 2		54.08	45.92

Table 5. One-way repeated-measures ANOVA of the RMS (μV) for each muscle among the three different practice methods in stage 3

Muscles	Slow practice(a)	Rapid power practice(b)	Practical combat practice(c)	Tamhane's T2 test
LTAM	170.44 ± 89.15	186.44 ± 70.54	248.11 ± 98.57	
LGM	102.11 ± 40.06	109.67 ± 40.39	164.78 ± 93.34	F = 10.362
LRFM	115.00 ± 46.01	147.78 ± 63.62	146.89 ± 51.29	
LEAOM	75.89 ± 19.72	117.22 ± 44.95	161.00 ± 66.70	
LLDM	86.44 ± 13.12	141.44 ± 39.28	130.89 ± 31.75	pab = .034
LDM	74.67 ± 17.73	118.33 ± 37.05	198.56 ± 117.24	
LTBM	62.11 ± 7.67	86.78 ± 24.87	120.44 ± 55.91	
LBM	66.22 ± 16.98	90.11 ± 35.46	164.78 ± 156.32	pac = .005

RTAM	173.89 ± 84.16	177.11 ± 57.73	191.00 ± 81.47	
RGM	50.56 ± 33.52	60.78 ± 33.02	110.33 ± 61.33	
RRFM	114.89 ± 88.27	120.44 ± 65.60	189.44 ± 105.13	pbc = .043
REAOM	47.67 ± 21.93	106.33 ± 58.92	148.89 ± 110.81	
RLDM	66.00 ± 9.76	112.67 ± 32.56	176.67 ± 50.26	
RDM	93.44 ± 14.01	187.44 ± 40.77	582.78 ± 124.07	
RTBM	79.67 ± 15.70	135.33 ± 34.15	471.00 ± 385.45	
RBM	118.22 ± 45.19	167.00 ± 36.83	397.33 ± 295.82	
Mean value	93.58 ± 37.70	129.05 ± 36.92	225.18 ± 136.72	

Stage 3 of the *Lanzhayi* movement

Stages 1 and 2 prepared the movement, whereas stage 3 was the principal force-generating phase. RMS values from stage 3 were compared across slow practice, rapid power practice, and practical combat practice using one-way repeated-measures analysis of variance.

Stage-3 RMS increased in the order slow practice < rapid power practice < practical combat practice (Table 5). Pairwise differences were significant between slow and rapid power practice (pab = .034), rapid power and practical combat practice (pbc = .043), and slow and practical combat practice (pac = .005).

To determine whether accumulated activity also differed across practice methods, stage-3 iEMG values were compared using one-way repeated-measures analysis of variance. Contribution rates were also calculated for each muscle to describe how relative muscular involvement changed among conditions.

The analysis showed no significant difference in muscle iEMG among the three practice methods (Table 6).

In slow practice, the five largest muscle contributions were from the right tibialis anterior, left tibialis anterior, right brachioradialis, right rectus femoris, and left rectus femoris (Figure 2). In rapid power practice, the five largest contributions were from the right deltoid, left tibialis anterior, right tibialis anterior, right brachioradialis, and left latissimus dorsi. In practical combat practice, the five largest contributions were from the right deltoid, right triceps brachii, right brachioradialis, left tibialis anterior, and left deltoid. Across slow, rapid power, and practical combat practice, the relative iEMG contribution of left-side trunk and upper-limb muscles decreased, whereas the contribution of right-side muscles increased (Table 7).

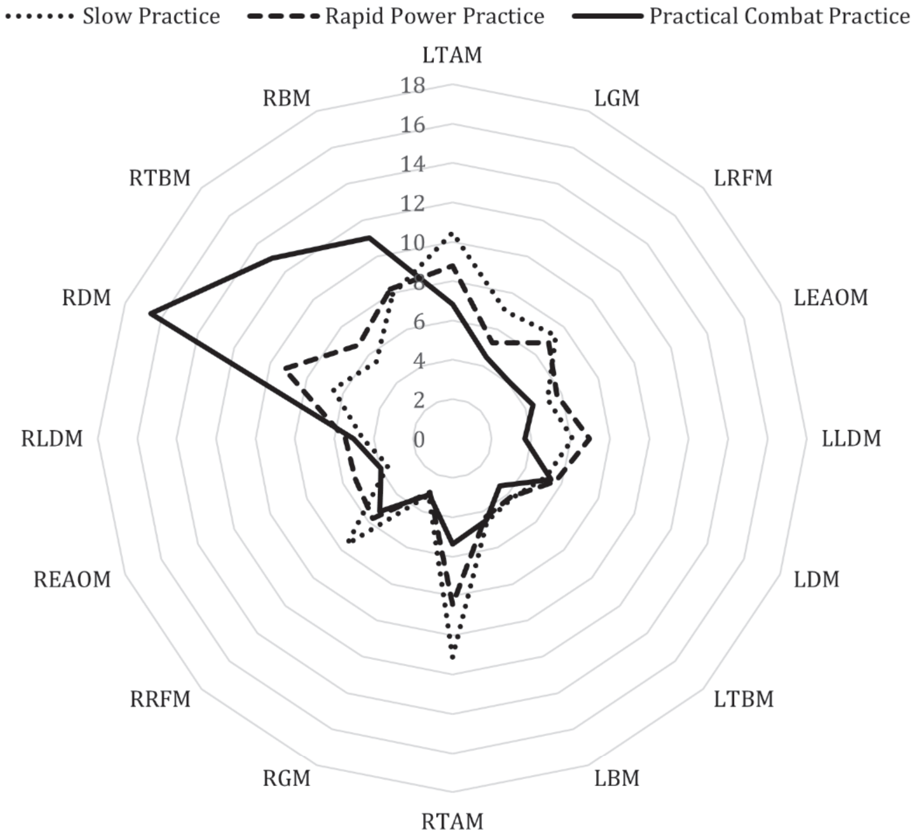

Figure 2. Stage 3 of the *Lanzhayi* movement: three practice methods' muscle contribution rate

Table 6. One-way repeated-measures ANOVA of iEMG (μV·s) for each muscle among the three different practice methods in stage 3

Muscles	Slow practice(a)	Rapid power practice(b)	Practical combat practice(c)	LSD test
LTAM	449.00 ± 151.52	462.33 ± 128.07	342.11 ± 128.64	F = 0.864
LGM	301.11 ± 137.74	278.11 ± 92.14	224.89 ± 106.76	
LRFM	317.67 ± 89.48	363.00 ± 111.54	204.33 ± 86.68	
LEAOM	224.22 ± 78.28	301.67 ± 118.71	222.78 ± 79.55	pab = .216
LLDM	261.67 ± 110.74	366.11 ± 107.92	184.22 ± 55.89	
LDM	220.22 ± 72.45	299.22 ± 67.22	272.33 ± 151.85	pac = .350
LTBM	183.44 ± 55.51	220.33 ± 47.75	170.33 ± 91.53	
LBM	195.00 ± 74.94	228.56 ± 78.33	224.89 ± 193.99	pbc = .758
RTAM	475.89 ± 169.82	444.11 ± 126.17	269.89 ± 134.49	
RGM	134.11 ± 70.13	156.22 ± 84.02	154.89 ± 76.94	
RRFM	325.11 ± 209.86	301.22 ± 131.29	263.11 ± 138.23	

REAOM	152.11 ± 121.06	281.22 ± 177.63	197.33 ± 123.19
RLDM	195.00 ± 58.97	286.33 ± 67.72	251.67 ± 73.20
RDM	281.67 ± 103.96	486.33 ± 131.55	833.00 ± 163.13
RTBM	235.56 ± 83.70	352.89 ± 106.37	651.00 ± 479.35
RBM	340.22 ± 118.35	432.67 ± 124.85	554.33 ± 379.35
Total	4292.00	5260.32	5021.10

Note. a = slow practice; b = rapid power practice; c = practical combat practice. F represents the F value of the repeated-measures ANOVA. pab, pac, and pbc represent the p values for pairwise comparisons between a and b, a and c, and b and c, respectively.

Table 7. Comparison of the contribution rates (%) of the left and right sides of the three practices in stage 3 of the *Lanzhayi* movement

Practice methods	Parts	Left side	Right side
Slow practice	Lower limbs	53.31	46.69
Rapid power practice		55.03	44.97
Practical combat practice		52.86	47.14
Slow practice	Trunk	58.33	41.67
Rapid power practice		54.06	45.94
Practical combat practice		47.55	52.45
Slow practice	Upper limbs	41.11	58.89
Rapid power practice		37.04	62.96
Practical combat practice		24.67	75.33
Slow practice	All muscles	50.15	49.85
Rapid power practice		47.89	52.11
Practical combat practice		36.76	63.24

Expert-case analysis of muscle activation sequence in stage 3

Activation order varied considerably among the nine participants and across the three practice methods. Averaging these sequences would have obscured individual timing; therefore, the sequence from participant 1, the professor with extensive theoretical and practical experience, was selected for descriptive analysis. Because EMG activation thresholds are partly subjective, previous studies have used values between 10% and 20% of peak amplitude. This study used 20% of each muscle's maximum amplitude to identify activation.

Table 8 yielded the following expert-case activation sequences:

Slow practice: the right brachioradialis and right tibialis anterior activated simultaneously, followed by the right triceps brachii; the right deltoid and right triceps brachii; the left rectus femoris, right external oblique, and left brachioradialis; the left deltoid; the left triceps brachii and right rectus femoris; the left external oblique; the left latissimus dorsi and right gastrocnemius; and the left gastrocnemius. The left tibialis anterior and right latissimus dorsi remained active throughout.

Table 8. Order of muscle activation (%) in the three practices of the expert subject for the *Lanzhayi* movement

Muscles	Slow practice	Rapid power practice	Practical combat practice
LTAM	——	36.14	——
LGM	38.18	——	——
LRFM	5.45	48.19	6.67
LEAOM	10.91	40.16	——
LLDM	14.55	44.18	——
LDM	7.27	40.16	46.67
LTBM	9.09	48.19	6.67
LBM	5.45	32.13	26.67
RTAM	0.00	24.10	——
RGM	14.55	44.18	33.33
RRFM	9.09	40.16	0.00
REAOM	5.45	44.18	——
RLDM	——	48.19	0.00
RDM	3.64	36.14	——
RTBM	3.64	44.18	——
RBM	0.00	8.03	53.33

Note. "——" indicates that the muscle remained active throughout the analysed stage.

Rapid power practice: activation began in the right brachioradialis, followed by the right tibialis anterior; the left brachioradialis; the left tibialis anterior and right deltoid; the left external oblique, left deltoid, and right rectus femoris; the left latissimus dorsi, right gastrocnemius, right external oblique, and right triceps brachii; and the left rectus femoris, left triceps brachii, and right latissimus dorsi. The left gastrocnemius remained active throughout.

Practical combat practice: activation began in the right rectus femoris, followed by the right latissimus dorsi; left triceps brachii; left brachioradialis; right gastrocnemius; left deltoid; and right brachioradialis. All other measured muscles remained active throughout.
During rapid power and practical combat practice, many muscles activated and reached peak activity almost simultaneously, indicating strong muscular synergy. This pattern is consistent with the loose, lively, elastic, and shaking force characteristics described in Tai Chi practice (Figure 3).

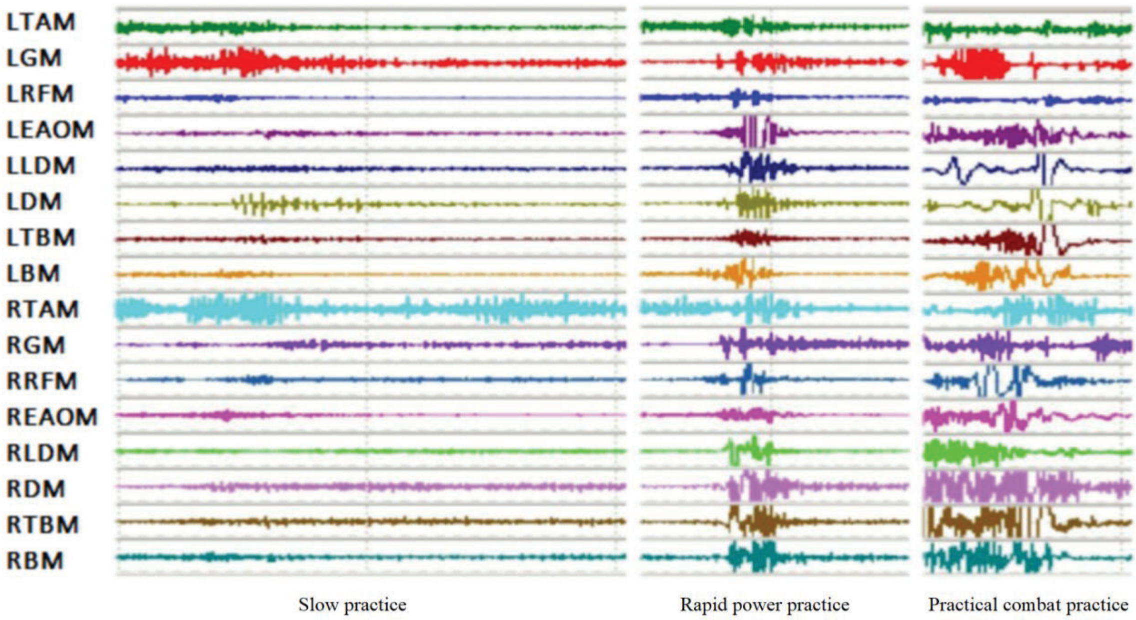

Figure 3. Electromyography of the three practices in stage 3 of the expert subject's *Lanzhayi* movement

Standing exercise of *Lanzhayi*

The standing exercise is a distinctive training method in Chinese martial arts. Although the practitioner maintains a fixed external posture, continuous internal postural adjustments are required. Previous studies suggest that standing exercises may support spinal stability, strengthen the lower-back and lower-limb muscles, and improve balance (Duan & Lin, 2019; Zhou et al., 2018). In this study, participants maintained the *Lanzhayi* standing posture for 60 s. iEMG and contribution rates were analysed, and participants' perceived responses were recorded after the exercise.
During the 60-s standing exercise, the five largest muscle contributions were from the left rectus femoris, right rectus femoris, left tibialis anterior, right brachioradialis, and right deltoid (Table 9). For the tibialis anterior, gastrocnemius, rectus femoris, external oblique, and latissimus dorsi, left-side iEMG exceeded right-side iEMG. By contrast, the deltoid, triceps brachii, and brachioradialis showed greater iEMG on the right than on the left.

The summed iEMG of the three measured lower-limb muscles was distributed between the left and right legs at approximately 6:4 (Table 10), differing from traditional estimates based on bodily perception.

Participants reported marked fatigue after approximately 30 s. Muscle shaking then became apparent, and by 60 s several participants had reached their tolerance limit and found it difficult to maintain the posture.

Table 9. iEMG (μV·s) and contribution rate (%) of each muscle of the subjects performing the standing exercise of *Lanzhayi*

Muscles	Left side	Contribution rate	Right side	Contribution rate
TAM	834.78 ± 227.17	17.14	287.56 ± 275.25	7.86
GM	504.67 ± 48.43	10.36	110.44 ± 51.34	3.02
RFM	838.44 ± 331.86	17.21	838.22 ± 333.63	22.90
EAOM	566.33 ± 41.52	11.63	83.78 ± 28.81	2.29
LDM	577.11 ± 63.49	11.85	496.22 ± 36.56	13.56
DM	573.89 ± 72.31	11.78	631.67 ± 186.76	17.26
TBM	508.44 ± 51.86	10.44	522.78 ± 59.85	14.28
BM	467.78 ± 44.25	9.60	689.89 ± 116.55	18.85

Table 10. Comparison of the muscle contribution rates (%) between the left and right sides of the subjects in the standing exercise of *Lanzhayi*

Part	Left side	Right side
Lower limbs	63.79	36.21
Trunk	66.35	33.65
Upper limbs	45.67	54.33
All muscles	57.10	42.90

Discussion

The findings show that practice method affected activation intensity, relative muscle contribution, and activation sequence during *Lanzhayi*.

Tai Chi training includes standing exercises, routine practice, pushing hands, and practical combat (Ma, 2003). These methods differ in how closely they reproduce an opponent-based task. In the present study, practical combat practice most closely approximated combat, followed by rapid power and slow practice. RMS increased significantly in the same order, indicating progressively greater activation intensity and motor-unit recruitment. In contrast, total iEMG did not differ significantly across methods. Thus, the practice methods changed the intensity and distribution of muscular activity more clearly than the total accumulated activity required to complete the movement.

Traditional Tai Chi theory describes power as beginning in the feet, passing through the legs, being controlled by the waist, and manifesting in the hands (Tang & Gu, 1996). This principle arose from holistic observation and bodily experience and has long guided practice. Zhou and Fan (2018) reported that the timing and range of motion of the ankle, knee, and hip during *Lanzhayi* were broadly compatible with this whole-body concept. However, the expert-case sEMG data in the present study did not show a fixed lower-limb-to-trunk-to-upper-limb activation sequence in stage 3. Ma (2017) similarly reported that muscle activation during Yanshou Hongchui did not follow a single fixed order. The early activation of muscles from different body segments in slow and rapid power practice is broadly consistent with Chen's (2004) description of coordinated action among distal, middle, and proximal sections. Rapid power practice concentrated activation around the force-generating instant, whereas practical combat practice required eight muscles to remain continuously active. Overall, the activation sequence varied with practice method.

Tai Chi movement is commonly interpreted through the interdependence of yin and yang. During the *Lanzhayi* standing posture, the left leg is described as the empty leg and the right as the solid leg; the right hand is described as yin and the left as yang. In the present data, left-leg iEMG exceeded right-leg iEMG, whereas right-arm iEMG exceeded left-arm iEMG. The authors interpret these asymmetries as consistent with the principle that yin contains yang and yang contains yin (Cai et al., 2017). The greater right-arm activation also agreed with participants' perception of greater fatigue in that arm. The greater activation of the nominally empty left leg, however, differed from the traditional expectation that the right leg bears substantially more weight.

A possible biomechanical explanation is that the body's centre of mass remained between the two legs in the bow-horse stance, allowing both limbs to support the trunk and upper body. Because the right tibia was nearly vertical, the right limb may have borne axial load with less activity from the tibialis anterior and gastrocnemius. The left lower-limb muscles may therefore have required greater activation to maintain the posture. Wu and Xiong (2012) reported greater iEMG in the rear leg than in the front leg during Santi stance, apparently because the supporting leg bore more body weight. The difference between that finding and the present result may reflect the distinct weight distribution and limb geometry of the two postures. Larger comparative studies are needed to test this explanation.

Conclusions

The left and right tibialis anterior muscles were the primary force-producing muscles in stages 1 and 2 of *Lanzhayi*. During stage 3, RMS differed significantly among slow practice, rapid power practice, and practical combat practice, with activation intensity increasing in that order. Total iEMG did not differ significantly, indicating that the practice methods differed more in activation intensity than in accumulated muscular activity.

In the expert-case analysis, stage-3 activation did not follow a fixed foot-leg-waist-hand sequence, and the order differed among slow practice, rapid power practice, and practical combat practice.

During the standing exercise, left-leg iEMG exceeded right-leg iEMG, whereas right-arm iEMG exceeded left-arm iEMG. These asymmetries may be interpreted through the Tai Chi concept that yin contains yang and yang contains yin, although the physiological pattern should be confirmed in larger samples.

Recommendations and limitations

Practitioners seeking combat-specific performance may benefit from training that more closely approximates practical combat, provided that appropriate safety measures and professional supervision are used.

The traditional principle that power begins in the feet, passes through the legs, is controlled by the waist, and manifests in the hands should be treated as guidance for whole-body coordination rather than as a literal, fixed sequence of muscle activation.

This study was limited by its small sample, the analysis of a single movement, the absence of MVC normalisation, and the use of one expert participant for activation-sequence analysis. Future research should include larger samples, normalised sEMG measures, multiple representative martial arts movements, and additional biomechanical tools. Such work may help describe traditional martial arts in scientifically interpretable terms while preserving their technical and cultural context.

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