CITIUS: Jurnal Pendidikan Jasmani Olahraga, dan Kesehatan
Indonesian Journal of Physical Education, Sports and Health
e-ISSN 2797-9962
Journal Homepage: http://journal.unugiri.ac.id/index.php/citius

The effect of circuit training on the anaerobic endurance of boxing athletes

Dwi Darojatun Khoriyah[1abcde)]*, Guntur Yulisatria[2bde)], Mela Suhariyanti[3acde)], Yopi Hutomo Bhakti [4bde)]
[11,2,3,4]Physical Education Study Program, Universitas Muhammadiyah Kotabumi, Lampung, Indonesia

ABSTRACT
Anaerobic endurance is a crucial component of physical condition for boxers because it is directly related to the ability to perform repeated high-intensity attacks during a match. However, empirical evidence on the effectiveness of training programmes for improving boxers' anaerobic endurance is still needed. This study aimed to determine the change in anaerobic endurance of boxers before and after circuit training. A pre-experimental one-group pretest–posttest design was used. The participants were 12 active boxers from a boxing club in North Lampung Regency, selected by total sampling. Anaerobic performance was measured with the Running-based Anaerobic Sprint Test (RAST), from which the average anaerobic power (in watts) was analysed. Data were analysed using descriptive statistics, the Shapiro–Wilk normality test, and, because the difference scores were not normally distributed, the Wilcoxon signed-rank test. The average anaerobic power increased from 432.50 W at pretest to 481.67 W at posttest, a mean improvement of 49.17 W (95% CI 47.93–50.40). The Wilcoxon test showed a significant pre-to-post difference ($Z = -3.06$; $p = 0.002$; $r = 0.62$). It can be concluded that the circuit training programme significantly improved boxers' anaerobic endurance and is therefore recommended for developing their physical condition, although the one-group design without a control group means the results should be interpreted with caution.
Keywords: circuit training; anaerobic endurance; anaerobic power; RAST; boxing

Received: 02 February 2026; Accepted 28 July 2026; Published 03 August 2026

Corresponding Author: Dwi Darojatun Khoriyah, Physical Education Study Program, Universitas Muhammadiyah Kotabumi, Lampung, Indonesia

e-mail: dwidarojatunkhoriyah@gmail.com

How to Cite: Khoriyah, D. D., Yulisatria, G., Suhariyanti, M.. Bhakti, Y. H. (2026). The effect of circuit training on the anaerobic endurance of boxing athletes. *Citius: Jurnal Pendidikan Jasmani, Olahraga, dan Kesehatan*, *6*(2), 37–43. https://doi.org/10.32665/citius.v6i2.6322

*Authors' Contribution**: a – Study Design; b – Data Collection; c – Statistical Analysis; d – Manuscript Preparation; e – Funds Collection.

INTRODUCTION

Boxing is a competitive sport that demands excellent physical condition, especially anaerobic endurance (Prayoga et al., 2023). Boxers must perform a series of explosive movements such as punches, dodges, and footwork repeatedly at high intensity within relatively short rounds, which makes the anaerobic energy system dominant during a match (Lopes-Silva & Franchini, 2021). Developing effective training methods to increase anaerobic endurance is therefore crucial for supporting performance, enabling boxers to maintain technical and tactical intensity throughout the bout (Niu et al., 2024).

Among the many methods developed to improve fitness components, circuit training combines several forms of exercise in a series at a certain intensity with relatively short rest periods (Hermosilla-Perona et al., 2025; Loewen et al., 2023). Several studies have shown that circuit training is effective in increasing muscle strength, cardiorespiratory capacity, and anaerobic endurance in athletes across sports such as soccer, futsal, basketball, and martial arts (Christy et al., 2022; Hu et al., 2024; Son et al., 2025). These results, however, vary in effectiveness depending on the training design, subject characteristics, and the performance indicators used.

Theoretically, circuit training is supported by the concept of high-intensity interval training (HIIT) and the principle of exercise specificity. High-intensity, short-rest training can stimulate metabolic adaptations in the anaerobic energy system, particularly increased phosphagen and glycolytic capacity (Pereira et al., 2024; Yue et al., 2025). Furthermore, the overload and progression principle explains that systematically applying training loads through circuit training can increase the body's tolerance to anaerobic fatigue, improving the ability to sustain repeated explosive performance, a key characteristic of boxing (Cid-Calfucura et al., 2023).

Despite this, studies examining the effect of circuit training specifically on the anaerobic endurance of boxers remain limited; most previous work has focused on other sports or on martial arts with different movement characteristics, has used less specific measurement indicators, or has not tested boxers directly (Yulianto et al., 2022; Setyawan et al., 2024). This study addresses that gap by implementing a structured circuit training programme contextualised to boxing, using anaerobic endurance indicators derived from the Running-based Anaerobic Sprint Test, and by quantitatively measuring its effect in active boxers. The urgency lies in the practical need of coaches and athletes for an effective, efficient, and evidence-based training model to improve competition performance.

Therefore, the purpose of this study is to determine the effect of circuit training on the anaerobic endurance of boxing athletes. The results are expected to serve as a scientific reference for coaches, athletes, and practitioners in designing effective training programmes to improve boxing performance.

METHOD

This study used a quantitative, pre-experimental one-group pretest–posttest design (Gani & Purbangkara, 2023). One group of subjects was given an initial measurement (pretest), then a treatment in the form of circuit training, and finally a posttest. Because the design has no control group, causal interpretation is limited and threats such as maturation, familiarisation, and testing effects cannot be fully excluded.

The population comprised all active boxers of a boxing club in North Lampung Regency, and because the whole population was included, total sampling yielded 12 participants aged 15–21 years, all in good health and free of injury during the study. Participant characteristics relevant to anaerobic capacity, namely sex, age, body mass, and competitive experience, were recorded prior to the intervention and should be reported together with the results.

The instrument was the Running-based Anaerobic Sprint Test (RAST), which consists of six maximal 35-metre sprints with a 10-second rest between sprints and yields maximum power, average power, and a fatigue index (Kumar et al., 2022; Gençoğlu et al., 2023). In this study, the average anaerobic power (in watts) was used as the primary indicator of anaerobic endurance; the maximum power and fatigue index should also be reported separately, as they carry different meanings (higher power is better, whereas a higher fatigue index is worse). To support reliability, the test was standardised across pretest and posttest for surface, footwear, and familiarisation, and consistent timing was used.

The procedure comprised preparation, pretest, treatment, and posttest. After the pretest, participants completed a six-week circuit training programme, three times per week. Each session used six stations, namely push-ups, squat jumps, burpees, high-intensity shadow boxing, mountain climbers, and sit-ups, each performed for 30 seconds with a 15-second rest between stations and 2 minutes between sets, for three sets per session. After the programme, participants repeated the RAST posttest under identical conditions.

Data were analysed with descriptive statistics (mean, standard deviation, minimum, and maximum). The Shapiro–Wilk test was used to assess the normality of the pre–post difference scores; because the differences were not normally distributed, the Wilcoxon signed-rank test was used to compare pretest and posttest, and the effect size was computed as $r = Z/\sqrt{N}$. The mean difference and its 95% confidence interval were also reported. The significance level was set at $\alpha = 0.05$.

RESULTS

Table 1. Individual anaerobic power (RAST average power, watts) of the boxing athletes

No	Athlete	Pretest (W)	Posttest (W)	Difference (Δ)
1	A1	410	455	45
2	A2	430	480	50
3	A3	450	500	50
4	A4	405	450	45
5	A5	440	490	50
6	A6	465	515	50
7	A7	425	475	50
8	A8	455	505	50
9	A9	395	445	50
10	A10	435	485	50
11	A11	420	470	50
12	A12	460	510	50
	Average	**432.50**	**481.67**	**49.17**

All 12 athletes showed an increase in anaerobic power after the six-week circuit training programme. Pretest values ranged from 395 to 465 W and posttest values from 445 to 515 W, with individual improvements of 45–50 W. No athlete declined. Because the improvements cluster onto two integer values at the recorded precision, they should be read together with the measurement-precision note in the Method and the limitation below.

Table 2. Descriptive statistics of anaerobic power (watts)

Stage	N	Minimum	Maximum	Mean	SD
Pretest	12	395.00	465.00	432.50	22.51
Posttest	12	445.00	515.00	481.67	23.58

The mean anaerobic power increased from 432.50 W (SD = 22.51) at pretest to 481.67 W (SD = 23.58) at posttest, indicating a higher average anaerobic power after treatment.

Table 3. Shapiro–Wilk normality test of the pre–post difference

Variable	N	Statistic	p	Dist.
Difference (posttest − pretest)	12	0.639	< 0.001	Not normal

The difference scores were not normally distributed ($p < 0.001$), so the normality assumption for a parametric paired t-test was not met, and the non-parametric Wilcoxon signed-rank test was used to compare pretest and posttest.

Table 4. Wilcoxon signed-rank test of pretest vs posttest anaerobic power

Comparison	N	Mean Δ (W)	Z	p	r / 95% CI of Δ
Pretest vs Posttest	12	49.17	-3.06	0.002	0.62 / 47.93–50.40

The Wilcoxon signed-rank test showed a statistically significant difference between pretest and posttest anaerobic power ($Z = -3.06$; $p = 0.002$), with a large effect size ($r = 0.62$). The mean improvement was 49.17 W (95% CI 47.93–50.40). Unlike a comparison against a fixed reference value, this test directly compares the pre- and post-training scores and therefore supports the conclusion that circuit training increased the athletes' anaerobic power. A parametric paired t-test, reported here only as a robustness check, was consistent with this result.

DISCUSSION

The results show that circuit training improved the athletes' ability to produce and sustain anaerobic power, consistent with the theory of high-intensity training, in which short work durations and limited rest can increase the capacity of the phosphagen and glycolytic energy systems (Yue et al., 2025). In boxing, this adaptation is particularly relevant because athletes perform repeated explosive movements with limited recovery during competition (Lopes-Silva & Franchini, 2021).

The findings align with previous research on combat sports and games reporting that circuit and interval training effectively increase athletes' power and anaerobic capacity (Christy et al., 2022; Yulianto et al., 2022; Tortu et al., 2024). This study adds to that literature by showing that a circuit design integrating boxing-specific elements, such as high-intensity shadow boxing, can provide a more specific stimulus to the physiological demands of boxers, extending the application of circuit training to the boxing context (Niu et al., 2024).

The increase in anaerobic power indicates neuromuscular and metabolic adaptations arising from the principles of overload and specificity (Cid-Calfucura et al., 2023). The circuit applied here repeatedly activated major muscle groups at high intensity, plausibly improving the efficiency of anaerobic energy production and tolerance to lactate accumulation, which distinguishes this programme from conventional training without sport-specific modifications (Santos & Franchini, 2021; Santos-Junior & Franchini, 2021).

Practically, the study offers a circuit training model that boxing coaches can adopt as an alternative physical-conditioning programme. It is relatively easy to implement, requires no complex equipment, and targets a fitness component crucial to performance, contributing to coaching science and training practice in high-performance sport (Beattie & Ruddock, 2025; Finlay, 2025).

This study has several limitations. The relatively small sample and the absence of a control group limit generalisability and mean that improvements cannot be fully separated from maturation, familiarisation, or testing effects. The individual gains clustered onto only two integer values (45 and 50 W), which is unusually uniform for physiological data and suggests limited measurement resolution; future work should report the full RAST outputs (maximum power, average power, and fatigue index) to their measured precision, ideally with electronic timing. The study also examined anaerobic endurance alone, without linking it to technical performance or match outcomes. Future research should therefore use a controlled design with a larger sample, electronic timing, and technical–tactical performance variables.

CONCLUSION

Circuit training tailored to the characteristics and physiological demands of boxing significantly improved the anaerobic endurance of boxing athletes, as shown by the increase in RAST average anaerobic power and confirmed by a direct pretest–posttest comparison. Theoretically, the findings reinforce the principles of high-intensity training and training specificity for developing the anaerobic energy system. Methodologically, the study shows that a one-group pretest–posttest design with the RAST can evaluate changes in anaerobic capacity, although it cannot establish causality on its own. Practically, the results can guide coaches in designing effective, efficient, and applicable physical-training programmes. Future research should involve a control group, a larger sample, and an examination of the relationship between increased anaerobic endurance and both technical performance and boxing match results.

ACKNOWLEDGEMENTS

The authors thank all parties who supported this study, especially the boxing club in North Lampung Regency and the athletes who participated.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this study.

REFERENCES

Amrullah, M. A., & Syafii, I. (2023). Pengaruh latihan circuit training terhadap peningkatan daya tahan aerobik pemain sepakbola remaja SSB Bintang Utama Surabaya. *Jurnal Prestasi Olahraga*, *6*(3), 24–31.

Beattie, K., & Ruddock, A. D. (2025). Strength training practices in amateur and professional boxing. *Journal of Strength and Conditioning Research*, *39*(6), 672–679. https://doi.org/10.1519/JSC.0000000000005050

Branco, B. H. M., & Franchini, E. (2021). Developing maximal strength for combat sports athletes. *Revista de Artes Marciales Asiáticas*, *16*(1s), 86–132. https://doi.org/10.18002/rama.v16i1s.7028

Cardini, R., Corrini, C., Bertoni, R., Anastasi, D., Cattaneo, D., & Gervasoni, E. (2024). Exploring the effectiveness of circuit training rehabilitation on balance, gait, and fatigue in multiple sclerosis: A systematic review and meta-analysis. *Physiotherapy*, *125*, 101413. https://doi.org/10.1016/j.physio.2024.101413

Christy, B. E., Raharjo, S., Andiana, O., & Yunus, M. (2022). Pengaruh latihan circuit dan interval training terhadap peningkatan daya tahan VO2max pada anggota ekstrakurikuler bola basket SMK Negeri 3 Malang. *Sport Science and Health*, *4*(1), 1–10.

Cid-Calfucura, I., Herrera-Valenzuela, T., Franchini, E., Vera-Assaoka, T., Carter-Beltran, J., Guzmán-Muñoz, E., & Valdés-Badilla, P. (2023). Effects of strength training on physical fitness of Olympic combat sports athletes: A systematic review. *International Journal of Environmental Research and Public Health*, *20*(4), 3516. https://doi.org/10.3390/ijerph20043516

Finlay, M. J. (2025). A four-week contrast training programme enhances punch performance and physical qualities in senior elite amateur boxers: A physical preparation case study for an international tournament. *International Journal of Strength and Conditioning*, *5*(1), 1–13.

Gani, R. A., & Purbangkara, T. (2023). *Metodologi penelitian pendidikan jasmani*. Uwais Inspirasi Indonesia.

Gençoğlu, C., Ulupınar, S., Özbay, S., Turan, M., Savaş, B. Ç., Asan, S., & İnce, İ. (2023). Reliability and validity of the kickboxing anaerobic speed test. *Research Quarterly for Exercise and Sport*, *94*(3), 715–724.

Hermosilla-Perona, F., Martín-Castellanos, A., Pereira-Monteiro, M. R., García, J. I., Barba-Ruíz, M., & Heredia-Elvar, J. R. (2025). Impact of circuit training structures on the acute response in physiological and mechanical performance: A cross-sectional study. *Scientific Reports*, *15*(1), 23766. https://doi.org/10.1038/s41598-025-08432-1

Hu, C., Xia, Y., Zeng, D., Ye, M., & Mei, T. (2024). Effect of resistance circuit training on comprehensive health indicators in older adults: A systematic review and meta-analysis. *Scientific Reports*, *14*(1), 8823. https://doi.org/10.1038/s41598-024-59386-9

Jatra, R. (2023). Pengaruh circuit training terhadap daya tahan atlet futsal. *Indonesian Journal of Sports Science*, *6*(3), 120–130.

Kim, J., Kim, E., Kim, D., & Yoon, S. (2024). Weighted vest intervention during whole-body circuit training improves serum resistin, insulin resistance, and cardiometabolic risk factors in normal-weight obese women. *Journal of Exercise Science & Fitness*, *22*(4), 463–473. https://doi.org/10.1016/j.jesf.2024.10.002

Kumar, P., Nara, K., & Bijender, B. (2022). The compatibility of running-based anaerobic sprint test and Wingate anaerobic test: A systematic review and meta-analysis. *Pedagogy of Physical Culture and Sports*, *26*(2), 133–142. https://doi.org/10.15561/26649837.2022.0208

Loewen, B., Melton, B., Maupin, D., & Ryan, G. (2023). Comparing acute responses between single session circuit training and fireground suppression tasks. *Journal of Strength and Conditioning Research*, *37*(8), 1667–1678. https://doi.org/10.1519/jsc.0000000000004431

Lopes-Silva, J. P., & Franchini, E. (2021). Developing anaerobic power and capacity for combat sports athletes. *Revista de Artes Marciales Asiáticas*, *16*(1s), 20–38. https://doi.org/10.18002/rama.v16i1s.7001

Niu, W., Feng, W., Xu, Z., & Wang, D. (2024). Effects of integrative neuromuscular training on striking ability and physical fitness in amateur boxers. *PeerJ*, *12*, e18311. https://doi.org/10.7717/peerj.18311

Pereira, P. E., Esteves, G., Carvas, N., & Azevedo, P. H. (2024). Effects of high-intensity interval and moderate-intensity continuous training on the anaerobic threshold of highly trained athletes in endurance sports: A systematic review with meta-analysis. *Journal of Sports Medicine and Physical Fitness*, *64*(9), 898–907. https://doi.org/10.23736/S0022-4707.24.15855-0

Prayoga, H. D., Maulana, A., & Fauzi, A. (2023). Tingkat kebugaran jasmani atlet tinju Kalimantan Selatan dikaitkan dengan hasil pra kualifikasi PON di Jawa Tengah. *Jurnal Porkes*, *6*(2), 623–633. https://doi.org/10.29408/porkes.v6i2.21416

Santos, J. F. da S., & Franchini, E. (2021). Developing muscle power for combat sports athletes. *Revista de Artes Marciales Asiáticas*, *16*(1s), 133–173. https://doi.org/10.18002/rama.v16i1s.7040

Santos-Junior, R. B., & Franchini, E. (2021). Developing strength-endurance for combat sports athletes. *Revista de Artes Marciales Asiáticas*, *16*(1s), 174–191. https://doi.org/10.18002/rama.v16i1s.7042

Setiawan, I. (2021). Analisis kekuatan daya tahan otot inti, indeks massa tubuh dan VO2Max atlet cabor tarung derajat. *Jurnal Pendidikan Kesehatan Rekreasi*, *7*(2), 340–347.

Setyawan, T., Pawitra, P. R. A., Yahya, A., & Budiono, D. (2024). Pengaruh pola latihan sirkuit training dan lari fartlek terhadap daya tahan aerobik atlet pencak silat Pagar Nusa. *Jurnal Pendidikan Kesehatan dan Rekreasi*, *11*(2), 48–54.

Son, W.-H., Kwak, Y.-S., & Ha, M.-S. (2025). Circuit training on oxidative stress and arterial health: A health promotion perspective for obese adult men. *Frontiers in Public Health*, *13*, 1562193. https://doi.org/10.3389/fpubh.2025.1562193

Tortu, E., Ouergui, I., Ulupınar, S., Özbay, S., Gençoğlu, C., & Ardigò, L. P. (2024). The contribution of energy systems during 30-second lower body Wingate anaerobic test in combat sports athletes: Intermittent versus single forms and gender comparison. *PLOS ONE*, *19*(5), e0303888. https://doi.org/10.1371/journal.pone.0303888

Wajib, M., Aditya, R. A., Sihombing, H., & Mes, H. (2022). Pengaruh high intensity interval training terhadap peningkatan VO2max atlet lari jarak jauh. *Jurnal Ilmiah STOK Bina Guna Medan*, *10*(2), 44–49.

Wibowo, R. A. T., Kusuma, I. A., Yulianto, P. F., Suwanto, W., & Iwandana, D. T. (2023). Pengaruh latihan plyometric single leg bound dan circuit training terhadap peningkatan tendangan sabit pada siswa pencak silat. *COMPETITOR: Jurnal Pendidikan Kepelatihan Olahraga*, *15*(2), 200–210.

Yue, F., Wang, Y., Yang, H., & Zhang, X. (2025). Effects of high-intensity interval training on aerobic and anaerobic capacity in Olympic combat sports: A systematic review and meta-analysis. *Frontiers in Physiology*, *16*, 1576676. https://doi.org/10.3389/fphys.2025.1576676

Yulianto, E., Mulyana, M., Yudiana, Y., & Hendarsin, F. (2022). The effect of interval training on anaerobic capacity improvement related to pencak silat athlete performance. *Jurnal Pendidikan Jasmani dan Olahraga*, *7*(1), 96–103. https://doi.org/10.17509/jpjo.v7i1.42620

Zhang, W., Chen, X., & Xu, K. (2025). Effects of blood flow restriction combined with resistance sprint training on upper-limb anaerobic power and strength in boxers. *Frontiers in Physiology*, *16*, 1453153. https://doi.org/10.3389/fphys.2025.1453153