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Tabata strength workout increases upper and lower body strength, and speed in Wushu Taolu Athletes

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ABSTRACT

This study aimed to prove the effect of the Tabata Strength Workout on increasing upper and lower body strength, and speed in Wushu Taolu athletes. A total of 22 male athletes aged 19-21 years were recruited from Wushu Taolu KONI, East Java, Indonesia, and divided into two study groups, including the control group and the Tabata strength workout group (*n*:11; CTR). Tabata strength workout interventions were carried out with a frequency of 4x/week for 8 weeks, with an intensity of 60-70% HRmax, duration of exercise 45-60 minutes/session, with the type of exercise total body workout body. The instrument used to measure upper body strength was a Chin-Up test, while lower body strength uses a vertical jump test. The speed was measured using a 20-meter Dash Test. The results obtained differences in upper body strength, lower body strength, and speed between CTR and TSW (0.18±0.98 at 1.91±0.83 (n); p=0.000), (0.36±1.86 at 6.64±1.75 (cm); p=0.000), and (0.01±0.04 at -0.09±0.11 (s); p=0.006). Tabata strength workout for 8 weeks has proven effective in increasing upper and lower body strength, and speed in Wushu Taolu athletes.

KEYWORDS

Speed; Tabata Strength Workout; Upper and Lower Body Strength; Wushu Taolu Athletes

1. INTRODUCTION

Combat sports, such as boxing and mixed martial arts (MMA), enjoy widespread popularity, with millions of followers and approximately 20% of summer Olympic medals attributed to these sports (Barley et al., 2019). The term "martial arts" is used to describe the totality of an empty-hand battle system originating from Eastern culture (Kruszewski, 2023). Among these, Wushu, a full-contact martial art originating from China, has evolved into a globally recognized modern sport. Wushu is a unique physical activity that combines health benefits, competitive aspects, and artistic expression (Cha & Jee, 2018; McAnulty et al., 2016). Wushu is divided into two events: 'Taolu' and 'Sansoo'. Both require postural control, which involves the integration of somatosensory (i.e., proprioception and cutaneous sensitivity), visual input, and vestibular systems in the central nervous system to produce motor output through the musculoskeletal system (Fong et al., 2023). Indeed, for Wushu athletes, the practice of muscle strength and speed is essential to reach their peak performance (Wang et al., 2024).

The development of effective training methods to enhance athletes' performance remains a compelling topic in sports science (Dong et al., 2023). Over the past decade, significant progress has been made in uncovering the cellular, molecular, and biochemical mechanisms modifiable through exercise (Furrer et al., 2023; Lavin et al., 2022; Hawley et al., 2014; Hargreaves, 2021; Lim et al., 2022; McGee & Hargreaves, 2020; Egan & Sharples, 2023). That is, the effect of exercise on the smallest unit of an organism (e.g. Athlete) has been revealed and can be modified. Human skeletal muscles display extraordinary plasticity, with the capacity to change both the type and amount of protein in response to cellular homeostasis disorders caused by the level of contracting activity, the availability of applicable substrates, and environmental conditions (Hawley et al., 2014; Hawley et al., 2011; Zierath & Hawley, 2004). Increased muscle mass is an important component of conditioning in various sports, especially to increase muscle cross-sectional area and muscle strength in supporting movements in wushu sports (Krzysztofik et al., 2019; Herman et al., 2010; Jones et al., 2008).

Increased muscle mass is a crucial component of conditioning in various sports, particularly for enhancing muscle cross-sectional area and strength to support movements in Wushu (Krzysztofik et al., 2019; Herman et al., 2010; Jones et al., 2008). All sports require special exercises, which are intended to improve muscle performance in terms of strength and explosive power and are based on strength exercise, namely repeated muscle contractions against weight, and this type of exercise produces significant muscle hypertrophy (Reggiani & Schiaffino, 2020). In addition, the results by

Lopez-Jaramillo et al. (2023) show evidence of the relationship between low muscle strength and various changes in metabolism, along with interventions that can increase cardiometabolic risk factors, while increasing muscle fitness. Mechanisms of potential exercise strength can mediate an increase in muscle mass with hypertrophy through the activation of endocrine signals by exercises, such as growth hormone, insulin-like growth factor 1, testosterone, thyroid hormone, and glucocorticoid (Castelli et al., 2023), nerve inputs also affect muscle development, modulate mass and strength. Among external stimuli that modulate these muscle features is physical exercise such as strength and endurance exercises. The result by Lu et al., (2023), also shows that strength exercise has many benefits for the body, including increasing muscle strength. Tabata Strength Workout has tiring power exercise characteristics, but is effective in increasing muscle adaptation, including increasing muscle strength, size, and muscle endurance (Schoenfeld et al., 2021). The gap in literature and the aim of the study despite the known benefits of strength exercises, there is a lack of research investigating the impact of specific training methods, such as the Tabata Strength Workout, on Wushu Taolu athletes. This study aims to address this gap by examining the effect of the Tabata Strength Workout on the upper and lower body strength, and speed of Wushu Taolu athletes.

2. METHODS

2.1. Study Design and Participants

This study was true experimental with a pretest-posttest control group design. A total of 22 male athletes aged 19-21 years were recruited from Wushu Taolu KONI, East Java (Indonesia), and divided into two study groups, including the control group (*n*:11; CTR), and Tabata Strength Workout group (*n*:11; TSW). The calculation of the study subject size using the Higgins & Kleinbaum formula (1985) with reference values from previous studies so that a minimum subject size was obtained and 22 participants were taken (Megahed et al., 2023). Informed consent was obtained from each subject voluntarily and without any coercion from any party. All protocols applied in this study have complied with a series of ethical principles regarding research involving human subjects developed by the World Medical Association.

2.2. Protocol of Tabata strength workout

Tabata strength workout was done with a frequency of 4x/week for 8 weeks, with an intensity of 60-70% HRmax, duration of exercise 45-60 minutes/session, with a total type of workout body workout (single leg jump, Russian twist, side lunges + barbel bar, hold squat, burpees, squat jump to box, plank & rotation, tap to shoulder) repetition and interspersed with active rest between sets of 10-

20 seconds. Warming up (dynamic stretching) and cooling down (static stretching) each are carried out for 5 minutes at low-intensity (Akbar et al., 2024; Pranoto et al., 2024). Meanwhile, the control group was not given any intervention. The development of the Tabata strength workout model refers to previous study (Tabata, 2019).

2.3. Research Instrument

The instrument used to measure upper body strength was a Chin-Up Test (Nelson et al., 1991), while lower body strength used a Vertical Jump Test (Vanegas et al., 2021). The speed was measured using a 20-meter Dash Test (Young et al., 2008). The instruments used in this research have been validated by previous studies (Nelson et al., 1991; Young et al., 2008; Vanegas et al., 2021). Each test was carried out between before intervention and 24 hours after intervention for 8 weeks. The test was carried out in one day with a time lag between the test items was 60 minutes.

2.4. Statistical Analyses

The data analysis technique begins with the normality prerequisites test using the Shapiro-Wilk normality test. The different tests of each group are carried out with paired sample t-tests. Meanwhile, the difference between groups was carried out with an independent sample t-test. All statistical analysis uses a significant level of 5% with the presentation of the data mean ± SD. All statistical analysis using SPSS software for Windows version 20.

3. RESULTS

The results of the analysis of the demographic characteristics of the research subject in the control group (CTR; *n*:11), and the Tabata Strength Workout group (TSW; *n*:11) are shown in Table 1.

Table 1. Demographic characteristics of research subjects

Variable	n	CTR	TSW	*p* value
		Mean±SD	Mean±SD	
Body weight (kg)	11	60.36±4.95	59.91±4.85	0.606
Body height (m)	11	1.67±0.05	1.67±0.06	0.902
Body mass index (kg/m^2)	11	21.61±1.01	21.38±0.71	0.830
Age (yrs)	11	20.36±0.81	20.55±0.82	0.543

The demographic characteristics were comparable between the CTR and TSW groups. No statistically significant differences were found in body weight (p = 0.606), body height (p = 0.902),

BMI (p = 0.830), or age (p = 0.543), as all p-values were greater than 0.05. The results of the analysis of upper and lower body strength, and speed in both groups are shown in Figure 1-2 and Table 2.

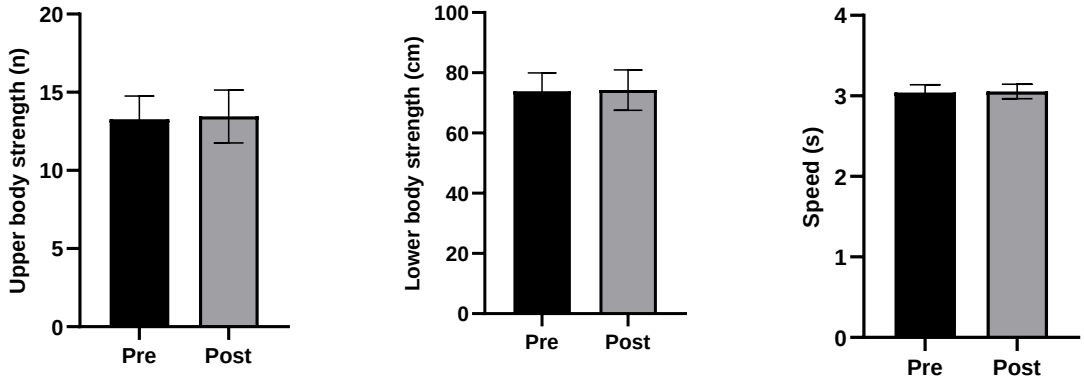

Figure 1. Upper and lower body strength, and speed in the control group

The results of the paired sample t-test analysis show that there was no significant difference in the average upper body strength, lower body strength, and speed between pre and post in CTR (13.27±1.49 at 13.46±1.69 (n); p=0.553), (73.91±6.03 at 74.27±6.69 (cm); p=0.531), and (3.04±0.09 at 3.06±0.09 (s); p=0.313).

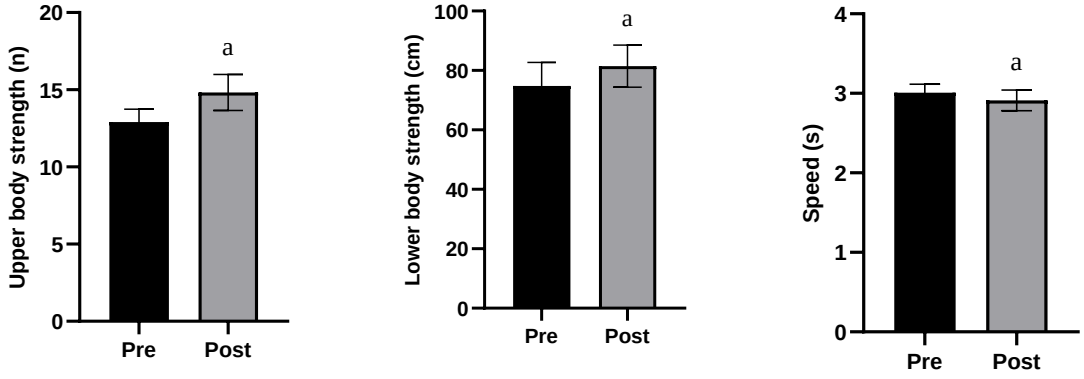

Figure 2. Upper and lower body strength, and speed in tabata strength workout group

The results of the paired sample t-test analysis show that there was a significant difference in the average upper body strength, lower body strength, and speed between pre and post in TSW (12.91±0.83 at 14.82±1.17 (n); p=0.000), (74.82±7.88 at 81.45±7.06 (cm); p=0.000), and (3.01±0.11 at 2.91±0.13 (s); p=0.011).

Table 2. Mean of upper and lower body strength, and speed in both groups

Variable	n	CTR	TSW	*p* value
		Mean±SD	Mean±SD	
Upper body strength (n)				
Pre	11	13.27±1.49	12.91±0.83	0.490
Post	11	13.45±1.69	14.82±1.17[a]	0.042
Difference (post – pre)	11	0.18±0.98	1.91±0.83[a]	0.000
Lower body strength (cm)				
Pre	11	73.91±6.02	74.82±7.88	0.765
Post	11	74.27±6.69	81.46±7.06[a]	0.024
Difference (post – pre)	11	0.36±1.86	6.64±1.75[a]	0.000
Speed (s)				
Pre	11	3.04±0.09	3.01±0.11	0.442
Post	11	3.06±0.09	2.91±0.13[a]	0.007
Difference (post – pre)	11	0.01±0.04	-0.09±0.11[a]	0.006

Note. ([a]) Significant at pre ($p \leq 0.05$); Sig. (2-tailed) obtained by independent sample t-test.

4. DISCUSSION

The results of our study showed that the Tabata Strength Workout conducted with an intensity of 60-70 1RM, 4x/week frequency for 8 weeks has been proven effective in increasing upper and lower body strength, and speed in wushu Taolu athletes. Tabata Strength Workout training is defined as training with a tiring intensity of the subject during the 7th or 8th set of 20-second bicycle training with a 10-second break between the training battle (Tabata, 2019). Tabata Strength Workout has tiring resistance training characteristics but is effective in increasing muscle adaptation, including increased muscle strength, size, and endurance of local muscles (Schoenfeld et al., 2021). These statements have strengthened our results. Another study also strengthens our report regarding Tabata strength training. They explained about strength training, and the training we proposed also included a type of strength training. They explain that strength exercises can improve performance in special martial arts tests, and strength exercises can improve different power manifestations, such as maximum strength, strength speed, and muscle strength as the physical condition of other variables (Cid-Calfucura et al., 2023). Our results prove that Tabata Strength Workout is effective in increasing the strength of the upper and lower body muscles, and speed in Wushu Taolu athletes.

Tabata Strength Workout has been considered one of the training methods that have a lot of exercises, such as training modes, intensity, and training and rest duration (Tabata, 2019). In this study, we applied Tabata Strength Workout exercises with an intensity of 60% - 70% 1RM, 4x/week frequency for 8 weeks. Strength exercises are highly recommended to increase muscle mass, strength, and physical function (Balachandran et al., 2023). "Motor Unit" in the muscles has long been considered a quantitative element in movement control formed by motor neurons and muscle fibers that are innervated by their axons (Stecco et al., 2023). A single motor unit never works alone; it always synergizes, not only with other motor units of the same muscles but also with different synergistic muscles (Stecco et al., 2023; Liu et al., 2002).

Tabata Strength Workout is a training modality that is widely used in improving the health conditions and performance of athletes (Colorni et al., 2023). During the competition, the athlete's body is required to be able to apply high-intensity exercise, which is characterized by a short time and interspersed with a recovery period making Tabata Strength Workout an effective training method option in increasing physical fitness, including muscle strength, and muscle durability (Lu et al., 2023; Laursen & Jenkins, 2002; Alzar-Teruel, et al., 2022). Various studies have reported that strength and power is an important component in obtaining champions between athletes from different competition levels, supporting medalists compared to non-medalists and between elite athletes versus non-elite (Cid-Calfucura et al., 2023; Harris et al., 2020; Roschel et al., 2009; Loturco et al., 2016; Marković et al., 2005; Sadowski et al., 2012; García Pallarés et al., 2012; Smith et al., 2000; Tsolakis & Vagenas, 2010). This may be due to the habituation of Tabata Strength Workout following the characteristics of martial arts sports, in addition to its benefits for increasing muscle strength.

Regular exercise is aimed at muscle conditioning for athletes. Tabata strength training is an effective muscle training method, as has been reported in this study. It is well known that the skeletal muscle has been considered to function as an autocrine, paracrine, and endocrine organ by releasing many myokines (Park et al., 2023). Its potential mechanism is due to Tabata strength workout triggering mitochondrial biogenesis (Gutiérrez-arroyo et al., 2023). Mitochondria contain relevant enzymes for cellular respiration, which is an important pathway for the regeneration of equivalent reduction and energy production in the form of adenosine triphosphate (ATP) (Shang et al., 2023). It is known that mitochondria are very important for cellular functions such as metabolism and apoptosis (Schäfer et al., 2023). Improvement of metabolic conditions in muscle cells due to exercise

affects the functional improvement of muscles marked by an increase in upper and lower body strength, and speed as reported in this study.

It is well-known that human muscles have two types of muscle fiber, that is fast-twitch muscle fibers generate high power in a short amount of time but are easily fatigued, whereas slow-twitch fibers are more fatigue-resistant (Llanos-Lagos, et al., 2024). Strength training is well known to have muscle hypertrophy characteristics (Reggiani & Schiaffino, 2020). Contrary, When the joint reaches a certain angle in resistance motion, the muscle force will be minimized, and the movement speed will decrease, called the sticking zone (Wang et al., 2023). Human skeletal muscle demonstrates remarkable plasticity, adapting to numerous external stimuli including the habitual level of contractile loading (Furrer et al., 2023). However, strength without speed is less effective in combat sports, especially wushu taolu. Therefore, the Tabata strength workout becomes the right solution in combat sports. It has been reported in this study that the Tabata strength workout has been proven to increase strength and speed. It can be concluded that Tabata strength workouts for 8 weeks have proven effective in increasing upper and lower body strength and speed in Wushu Taolu athletes. The limitation of this research is that in improving the performance of Wushu athletes, we only used two parameters. Suggestions for further research include adding biomolecular parameters to see the effect of Tabata strength workouts on strength and speed in supporting the performance of Wushu athletes.

5. CONCLUSIONS

The results of this study suggest that the Tabata strength workout, which is carried out with an intensity of 60–70% HRmax and 4x/week frequency for 8 weeks, may have a positive effect on upper and lower body strength, and speed in Wushu Taolu athletes. However, this study has some limitations, such as the small sample size, lack of blinding, potential biases, or other methodological constraints. Therefore, the causal relationship between the Tabata strength workouts and improvements in strength and speed cannot be established with certainty. Further research is needed to confirm these findings and to explore the underlying mechanisms of the Tabata strength workout on Wushu Taolu performance. The results of this study can provide some preliminary insights for trainers and athletes in designing effective training programs to enhance physical fitness and performance.

6. REFERENCES

1. Akbar, B., Setijono, H., Wiriawan, O., Wahyono, M., Nuryadi, A., Purwoto, S. P., & Pranoto, A. (2024). Increased leg muscle strength and power after 6 weeks of trapping exercise in male college students. *SPORT TK-Revista EuroAmericana de Ciencias del Deporte, 13*, 1-7. https://doi.org/10.6018/sportk.551551
2. Alzar-Teruel, M., Aibar-Almazán, A., Hita-Contreras, F., Carcelén-Fraile, M. D. C., Martínez-Amat, A., Jiménez-García, J. D., Fábrega-Cuadros, R., & Castellote-Caballero, Y. (2022). High-intensity interval training among middle-aged and older adults for body composition and muscle strength: A systematic review. *Frontiers in Public Health, 10*, 1-12. https://doi.org/10.3389/fpubh.2022.992706
3. Balachandran, A.T., Wang, Y., Szabo, F., Watts-Battey, C., Schoenfeld, B. J., Zenko, Z., & Quiles, N. (2023). Comparison of traditional vs. lighter load strength training on fat-free mass, strength, power and affective responses in middle and older-aged adults: A pilot randomized trial. *Experimental Gerontology, 178*, 1-12. https://doi.org/10.1016/j.exger.2023.112219
4. Barley, O. R., Chapman, D. W., Guppy, S. N., & Abbiss, C. R. (2019). Considerations When Assessing Endurance in Combat Sport Athletes. *Frontiers in Physiology, 10*, 1-9. https://doi.org/10.3389/fphys.2019.00205.
5. Bu X. (2022). Experimental Study on the Effect of Speed Strength Training on the Special Strikes of Chinese Female Boxers. *Journal of Environmental and Public Health, 2022*(4), 1-7. https://doi.org/10.1155/2022/5912231
6. Castelli, F., Valero-Breton, M., Hernandez, M., Guarda, F., Cornejo, J., Cabello-Verrugio, C., & Cabrera, D. (2023). Regulatory Mechanisms of Muscle Mass: The Critical Role of Resistance Training in Children and Adolescent. *Advances in Experimental Medicine and Biology, 1410*, 21–34. https://doi.org/10.1007/5584_2022_743
7. Cha, J. Y., & Jee, Y. S. (2018). Wushu Nanquan training is effective in preventing obesity and improving heart function in youth. *Journal of Exercise Rehabilitation, 14*(3), 466–472. https://doi.org/10.12965/jer.1836238.119
8. Cid-Calfucura, I., Herrera-Valenzuela, T., Franchini, E., Falco, C., Alvial-Moscoso, J., Pardo-Tamayo, C., Zapata-Huenullán, C., Ojeda-Aravena, A., & 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), 1-16. https://doi.org/10.3390/ijerph20043516
9. Colorni, E., Ohayon, E., Côté, J. N., Obolski, U., & Halperin, I. (2023). Should I Rest or Should I Go Now? A Randomized Cross-Over Trial Comparing Fixed and Self-Selected Rest Durations in High-Intensity Interval Training Cycling Sessions. *Sports Medicine - Open, 9*(1), 1-11. https://doi.org/10.1186/s40798-023-00601-8
10. Dong, K., Yu, T., & Chun, B. (2023). Effects of Core Training on Sport-Specific Performance of Athletes: A Meta-Analysis of Randomized Controlled Trials. *Behavioral Sciences (Basel, Switzerland), 13*(2), 1-13. https://doi.org/10.3390/bs13020148
11. Egan, B., & Sharples, A. P. (2023). Molecular responses to acute exercise and their relevance for adaptations in skeletal muscle to exercise training. *Physiological Reviews, 103*(3), 2057–2170. https://doi.org/10.1152/physrev.00054.2021
12. Fong, S. S. M., Chung, L. M. Y., Yam, T. T. T., Chung, J. W. Y., Bae, Y. H., Gao, Y., Chan, J. S. M., & Wang, H. K. (2023). Effects of Ving Tsun sticking-hand training on lower limb sensorimotor performance among community-dwelling middle-aged and older adults: a randomized controlled trial. *Trials, 24*(1), 1-8. https://doi.org/10.1186/s13063-023-07133-2

13. Furrer, R., Hawley, J. A., & Handschin, C. (2023). The molecular athlete: exercise physiology from mechanisms to medals. *Physiological Reviews, 103*(3), 1693–1787. https://doi.org/10.1152/physrev.00017.2022
14. García Pallarés, J., López-Gullón, J. M., Torres-Bonete, M. D., & Izquierdo, M. (2012). Physical fitness factors to predict female Olympic wrestling performance and sex differences. *Journal of Strength and Conditioning Research, 26*(3), 794–803. https://doi.org/10.1519/JSC.0b013e31824741e7
15. Gutiérrez-Arroyo, J., García-Heras, F., Carballo-Leyenda, B., Villa-Vicente, J. G., Rodríguez-Medina, J., & Rodríguez-Marroyo, J. A. (2023). Effect of a High-Intensity Circuit Training Program on the Physical Fitness of Wildland Firefighters. *International Journal of Environmental Research and Public Health, 20*(3), 1-13. https://doi.org/10.3390/ijerph20032073
16. Hargreaves M. (2021). Exercise and health: historical perspectives and new insights. *Journal of Applied Physiology, 131*(2), 575–588. https://doi.org/10.1152/japplphysiol.00242.2021
17. Harris, D. M., Kendall, K., Haff, G. G., & Latella, C. (2020). Absolute and Relative Strength, Power and Physiological Characteristics of Indian Junior National-Level Judokas. *Sports (Basel, Switzerland), 8*(2), 1-12. https://doi.org/10.3390/sports8020014
18. Hawley, J. A., Burke, L. M., Phillips, S. M., & Spriet, L. L. (2011). Nutritional modulation of training-induced skeletal muscle adaptations. *Journal of Applied Physiology, 110*(3), 834–845. https://doi.org/10.1152/japplphysiol.00949.2010
19. Hawley, J. A., Hargreaves, M., Joyner, M. J., & Zierath, J. R. (2014). Integrative biology of exercise. *Cell, 159*(4), 738–749. https://doi.org/10.1016/j.cell.2014.10.029
20. Herman, J. R., Rana, S. R., Chleboun, G. S., Gilders, R. M., Hageman, F. C., Hikida, R. S., Kushnick, M. R., Ragg, K. E., Staron, R. S., & Toma, K. (2010). Correlation Between Muscle Fiber Cross-Sectional Area and Strength Gain Using Three Different Resistance-Training Programs In College-Aged Women. *Journal of Strength and Conditioning Research, 24*, 1-12. https://doi.org/10.1097/01.jsc.0000367128.04768.0a
21. Higgins, J. K., & Kleimbaun, A. P. (1985). Design Methodology for Randomized Clinical Trials; Family Health International: Arlington, VA, USA, pp. 24–25.
22. Jones, E. J., Bishop, P. A., Woods, A. K., & Green, J. M. (2008). Cross-sectional area and muscular strength: a brief review. *Sports Medicine (Auckland, N.Z.), 38*(12), 987–994. https://doi.org/10.2165/00007256-200838120-00003
23. Kruszewski A. (2023). From Ancient Patterns of Hand-to-Hand Combat to a Unique Therapy of the Future. *International Journal of Environmental Research and Public Health, 20*(4), 1-14. https://doi.org/10.3390/ijerph20043553
24. Krzysztofik, M., Wilk, M., Wojdała, G., & Gołaś, A. (2019). Maximizing Muscle Hypertrophy: A Systematic Review of Advanced Resistance Training Techniques and Methods. *International Journal of Environmental Research and Public Health, 16*(24), 1-14. https://doi.org/10.3390/ijerph16244897
25. Laursen, P. B., & Jenkins, D. G. (2002). The scientific basis for high-intensity interval training: optimising training programmes and maximising performance in highly trained endurance athletes. *Sports Medicine (Auckland, N.Z.), 32*(1), 53–73. https://doi.org/10.2165/00007256-200232010-00003
26. Lavin, K. M., Coen, P. M., Baptista, L. C., Bell, M. B., Drummer, D., Harper, S. A., Lixandrão, M. E., McAdam, J. S., O'Bryan, S. M., Ramos, S., Roberts, L. M., Vega, R. B., Goodpaster, B. H., Bamman, M. M., & Buford, T. W. (2022). State of Knowledge on Molecular Adaptations to Exercise in Humans: Historical Perspectives and Future Directions. *Comprehensive Physiology, 12*(2), 3193–3279. https://doi.org/10.1002/cphy.c200033.
27. Lim, C., Nunes, E. A., Currier, B. S., McLeod, J. C., Thomas, A. C. Q., & Phillips, S. M. (2022). An Evidence-Based Narrative Review of Mechanisms of Resistance Exercise-Induced Human

Skeletal Muscle Hypertrophy. *Medicine and Science in Sports and Exercise*, *54*(9), 1546–1559. https://doi.org/10.1249/MSS.0000000000002929
28. Liu, J. Z., Brown, R. W., & Yue, G. H. (2002). A dynamical model of muscle activation, fatigue, and recovery. *Biophysical Journal*, *82*(5), 2344–2359. https://doi.org/10.1016/S0006-3495(02)75580-X
29. Lievens, E., Klass, M., Bex, T., & Derave, W. (2020). Muscle fiber typology substantially influences time to recover from high-intensity exercise. *Journal of Applied Physiology*, *128*(3), 648–659. https://doi.org/10.1152/japplphysiol.00636.2019
30. Lu, Y., Wiltshire, H. D., Baker, J. S., Wang, Q., & Ying, S. (2023). The effect of Tabata-style functional high-intensity interval training on cardiometabolic health and physical activity in female university students. *Frontiers in Physiology*, *14*, 1-19. https://doi.org/10.3389/fphys.2023.1095315
31. Lopez-Jaramillo, P., Lopez-Lopez, J. P., Tole, M. C., & Cohen, D. D. (2023). Increasing muscular strength to improve cardiometabolic risk factors. *Clinica e Investigacion en Arteriosclerosis*, *35*(3), 144–154. https://doi.org/10.1016/j.arteri.2022.12.002
32. Loturco, I., Nakamura, F. Y., Lopes-Silva, J. P., Silva-Santos, J. F., Pereira, L. A., & Franchini, E. (2016). Physical and physiological traits of a double world karate champion and responses to a simulated kumite bout: A case study. *International Journal of Sports Science & Coaching*, *12*(1), 138–147. https://doi.org/10.1177/1747954116684395
33. Marković, G., Misigoj-Duraković, M., & Trninić, S. (2005). Fitness profile of elite Croatian female taekwondo athletes. *Collegium Antropologicum*, *29*(1), 93–99.
34. McAnulty, S., McAnulty, L., Collier, S., Souza-Junior, T. P., & McBride, J. (2016). Tai Chi and Kung-Fu practice maintains physical performance but not vascular health in young versus old participants. *The Physician and Sportsmedicine*, *44*(2), 184–189. https://doi.org/10.1080/00913847.2016.1158623
35. McGee, S. L., & Hargreaves, M. (2020). Exercise adaptations: molecular mechanisms and potential targets for therapeutic benefit. *Nature reviews. Endocrinology*, *16*(9), 495–505. https://doi.org/10.1038/s41574-020-0377-1
36. Megahed, M., Al-Torbany, M., Al-Ghool, M., & Tarek, Z. (2023). Effects of high-intensity interval training using “Tabata protocol” on respiratory parameters, special endurance, and 800-m runners’ performance. *Journal of Human Sport and Exercise*, *18*(4), 842–857. https://doi.org/10.14198/jhse.2023.184.09
37. Nelson, J. K., Yoon, S. H., & Nelson, K. R. (1991). A field test for upper body strength and endurance. *Research Quarterly for Exercise and Sport*, *62*(4), 436–441. https://doi.org/10.1080/02701367.1991.10607546
38. Park, S. Y., Hwang, B. O., & Song, N. Y. (2023). The role of myokines in cancer: crosstalk between skeletal muscle and tumor. *BMB reports*, *5922*. Advance online publication.
39. Pranoto, A., Ramadhan, R. N., Rejeki, P. S., Miftahussurur, M., Yosika, G. F., Nindya, T. S., Lestari, B., & Halim, S. (2024). The role of long-term combination training in reducing and maintaining of body fat in obese young adult women. *Retos*, *53*, 139–146. https://doi.org/10.47197/retos.v53.102460
40. Reggiani, C., & Schiaffino, S. (2020). Muscle hypertrophy and muscle strength: dependent or independent variables? A provocative review. *European Journal of Translational Myology*, *30*(3), 1-12. https://doi.org/10.4081/ejtm.2020.9311
41. Roschel, H., Batista, M., Monteiro, R., Bertuzzi, R. C., Barroso, R., Loturco, I., Ugrinowitsch, C., Tricoli, V., & Franchini, E. (2009). Association between neuromuscular tests and kumite performance on the brazilian karate national team. *Journal of Sports Science & Medicine*, *8*(CSSI3), 20–24.

42. Sadowski, J., Gierczuk, D., Miller, J., & Cieśliński, I. (2012). Success factors in elite WTF taekwondo competitors. *Archives of Budo, 8*(3), 141-146. https://doi.org/10.12659/aob.883279
43. Schäfer, J. A., Sutandy, F. X. R., & Münch, C. (2023). Omics-based approaches for the systematic profiling of mitochondrial biology. *Molecular Cell, 83*(6), 911–926. https://doi.org/10.1016/j.molcel.2023.02.015
44. Schoenfeld, B. J., Grgic, J., Van Every, D. W., & Plotkin, D. L. (2021). Loading Recommendations for Muscle Strength, Hypertrophy, and Local Endurance: A Re-Examination of the Repetition Continuum. *Sports (Basel, Switzerland), 9*(2), 1-25. https://doi.org/10.3390/sports9020032
45. Shang, E., Nguyen, T. T. T., Westhoff, M. A., Karpel-Massler, G., & Siegelin, M. D. (2023). Targeting cellular respiration as a therapeutic strategy in glioblastoma. *Oncotarget, 14*, 419–425. https://doi.org/10.18632/oncotarget.28424
46. Smith, M. S., Dyson, R. J., Hale, T., & Janaway, L. (2000). Development of a boxing dynamometer and its punch force discrimination efficacy. *Journal of Sports Sciences, 18*(6), 445–450. https://doi.org/10.1080/02640410050074377
47. Stecco, A., Giordani, F., Fede, C., Pirri, C., De Caro, R., & Stecco, C. (2023). From Muscle to the Myofascial Unit: Current Evidence and Future Perspectives. *International Journal of Molecular Sciences, 24*(5), 1-13. https://doi.org/10.3390/ijms24054527
48. Tabata I. (2019). Tabata training: one of the most energetically effective high-intensity intermittent training methods. *The Journal of Physiological Sciences, 69*(4), 559–572. https://doi.org/10.1007/s12576-019-00676-7
49. Tsolakis, C., & Vagenas, G. (2010). Anthropometric, Physiological and Performance Characteristics of Elite and Sub-elite Fencers. *Journal of Human Kinetics, 23*(1), 89-95. https://doi.org/10.2478/v10078-010-0011-8
50. Vanegas, E., Salazar, Y., Igual, R., & Plaza, I. (2021). Force-Sensitive Mat for Vertical Jump Measurement to Assess Lower Limb Strength: Validity and Reliability Study. *JMIR mHealth and uHealth, 9*(4), 1-15. https://doi.org/10.2196/27336
51. Wang, X., Lv, C., Qin, X., Ji, S., & Dong, D. (2023). Effectiveness of plyometric training vs. complex training on the explosive power of lower limbs: A Systematic review. *Frontiers in Physiology, 13,* 1-15. https://doi.org/10.3389/fphys.2022.1061110
52. Wang, X., Soh, K. G., Deng, N., Zhang, D., Cao, S., & Samsudin, S. (2024). Effects of functional training on muscle strength, jumping, and functional movement screen in wushu athletes: A systematic review. *Heliyon, 10*(2), 1-12. https://doi.org/10.1016/j.heliyon.2024.e24087
53. Young, W., Russell, A., Burge, P., Clarke, A., Cormack, S., & Stewart, G. (2008). The use of sprint tests for assessment of speed qualities of elite Australian rules footballers. *International Journal of Sports Physiology and Performance, 3*(2), 199–206. https://doi.org/10.1123/ijspp.3.2.199
54. Zierath, J. R., & Hawley, J. A. (2004). Skeletal muscle fiber type: influence on contractile and metabolic properties. *PLoS Biology, 2*(10), 1523-1527. https://doi.org/10.1371/journal.pbio.0020348

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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