

# Combat sports in contemporary society: an interdisciplinary exploration

**Edited by**

Lazar Toskić, Leonardo Jose Mataruna-Dos-Santos,  
Alex Ojeda-Aravena, Leonardo Vidal Andreato and  
Jimmy Youn

**Published in**

Frontiers in Sports and Active Living  
Frontiers in Psychology  
Frontiers in Nutrition



## FRONTIERS EBOOK COPYRIGHT STATEMENT

The copyright in the text of individual articles in this ebook is the property of their respective authors or their respective institutions or funders. The copyright in graphics and images within each article may be subject to copyright of other parties. In both cases this is subject to a license granted to Frontiers.

The compilation of articles constituting this ebook is the property of Frontiers.

Each article within this ebook, and the ebook itself, are published under the most recent version of the Creative Commons CC-BY licence. The version current at the date of publication of this ebook is CC-BY 4.0. If the CC-BY licence is updated, the licence granted by Frontiers is automatically updated to the new version.

When exercising any right under the CC-BY licence, Frontiers must be attributed as the original publisher of the article or ebook, as applicable.

Authors have the responsibility of ensuring that any graphics or other materials which are the property of others may be included in the CC-BY licence, but this should be checked before relying on the CC-BY licence to reproduce those materials. Any copyright notices relating to those materials must be complied with.

Copyright and source acknowledgement notices may not be removed and must be displayed in any copy, derivative work or partial copy which includes the elements in question.

All copyright, and all rights therein, are protected by national and international copyright laws. The above represents a summary only. For further information please read Frontiers' Conditions for Website Use and Copyright Statement, and the applicable CC-BY licence.

ISSN 1664-8714  
ISBN 978-2-8325-6046-4  
DOI 10.3389/978-2-8325-6046-4

## About Frontiers

Frontiers is more than just an open access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

## Frontiers journal series

The Frontiers journal series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the *Frontiers journal series* operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

## Dedication to quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews. Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

## What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the *Frontiers journals series*: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area.

Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers editorial office: [frontiersin.org/about/contact](https://frontiersin.org/about/contact)

# Combat sports in contemporary society: an interdisciplinary exploration

## Topic editors

Lazar Toskić — University of Pristina, Serbia

Leonardo Jose Mataruna-Dos-Santos — Canadian University of Dubai, United Arab Emirates

Alex Ojeda-Aravena — Universidad de Los Lagos, Chile

Leonardo Vidal Andreato — University of the State of Amazonas, Brazil

Jimmy Youn — Hwasung Medi-Science University, Republic of Korea

## Citation

Toskić, L., Mataruna-Dos-Santos, L. J., Ojeda-Aravena, A., Andreato, L. V., Youn, J., eds. (2025). *Combat sports in contemporary society: an interdisciplinary exploration*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-6046-4

# Table of contents

04	<b>Editorial: Combat sports in contemporary society: an interdisciplinary exploration</b> Lazar Toskić
06	<b>In-contest body acceleration profiles for the judo male and female weight divisions</b> Luis Santos, Peter A. Federolf, Friedemann Schneider, Elena Pocecco, Javier Fernández-Río, Eliseo Iglesias-Soler, Eduardo Carballeira-Fernández, Sugoi Uriarte and Xurxo Dopico-Calvo
15	<b>What is hindering Chinese women from participating in combat sports?</b> Yike Li, Hansen Li, Dongchen Li, Xing Zhang, Zhenhuan Wang, Thomas Green and Guodong Zhang
21	<b>An ethnography of construction and characteristics of curriculum for inheritance of intangible cultural heritage martial arts in universities</b> Yuanlong Cheng and Nana Guo
42	<b>Relationship of selected conditioning parameters and sport performance indicators in karate</b> Kristina Nema, Pavel Ruzbarsky, Łukasz Rydzik and Tomas Peric
50	<b>Neuropsychological impact of Sanda training on athlete attention performance</b> Yuzhu Teng, Hailan Wu, Xiaoyun Zhou, Feiyang Li, Zhong Dong, Huafeng Wang, Kai Wang and Qianchun Yu
59	<b>A comparative analysis of punching in boxing and sanda: kinematic differences based on the cross and uppercut</b> QingLou Xu, Ruiqiu Mao and Changjin Xi
68	<b>Cultural hybridity and body image formation: exploring the experiences of Wushu male practitioners at the Siberian Chinese Martial Arts Center</b> Ekaterina A. Santanna and Benqian Li
74	<b>The role of the opponent's head in perception of kick target location in martial arts</b> M. R. Incognito, T. Watson, G. Weidemann and K. A. Steel
84	<b>Determination of weight loss methods and effects among wrestlers before an official championship</b> Ramazan Seker, Ozkan Isik, Erdil Durukan, Meric Eraslan, Laurentiu-Gabriel Talaghir and Viorel Dorgan
93	<b>Mental preparation of karateka for sports competition in kata</b> Paweł Adam Piepiora, Julia Barbara Jurczyk and Jolita Vveinhardt
99	<b>Getting small to feel big: the psychology of weight cutting in combat sports</b> Jacob J. Levy and Christopher Boyd





## OPEN ACCESS

EDITED AND REVIEWED BY  
Olivier Girard,  
University of Western Australia, Australia

## \*CORRESPONDENCE

Lazar Toskić  
✉ [lazar.toskic@pr.ac.rs](mailto:lazar.toskic@pr.ac.rs)

RECEIVED 30 January 2025

ACCEPTED 03 February 2025

PUBLISHED 12 February 2025

## CITATION

Toskić L (2025) Editorial: Combat sports in contemporary society: an interdisciplinary exploration.

Front. Sports Act. Living 7:1568909.

doi: 10.3389/fspor.2025.1568909

## COPYRIGHT

© 2025 Toskić. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# Editorial: Combat sports in contemporary society: an interdisciplinary exploration

Lazar Toskić<sup>1,2\*</sup>

<sup>1</sup>Faculty of Sport and Physical Education, University of Priština-Kosovska Mitrovica, Leposavić, Serbia,

<sup>2</sup>Faculty of Sport, University "Union-Nikola Tesla", Belgrade, Serbia

## KEYWORDS

combat sports, technique, physiology, psychology, biomechanics, performance, socio-culture

## Editorial on the Research Topic

**Combat sports in contemporary society: an interdisciplinary exploration**

Combat sports have come a long way from traditional martial arts, whose main practical purposes were self-defence and warfare, to the type of physical activity that is included in every cultural and educational aspect of sport. Today, as their social and health benefits have been well recognised, combat sports are an indispensable part of the sports scene, with thousands of competitors, globally reputed athletes of high impact, and grand competitions supported by marketing and sponsorship. Furthermore, combat sports are part of the physical education curriculum in schools and training systems for socially important, security-related professions (police, military etc.), allowing for the adequate growth and development of children and youth, mastery of self-defence skills, and ensuring personal and public safety. Finally, combat sports are a popular recreational activity with a constant increase in participants.

The special issue of *Combat sports in contemporary society: an interdisciplinary exploration* aims to bridge the fields of physiological, psychological, sociological, and technological studies. The majority of the published articles explore the technique, biomechanics and performance issues in various combat sports. Santos et al. investigated the Body Acceleration (BA) profile in a judo contest in the male and female weight divisions. Subjects participating in a 5-min simulated match contest against a same-sex opponent from the same weight division wore an accelerometer to record heart rate, blood lactate and ratings of perceived exertion. The study results revealed the differences in the athletes' BA and three distinct profiles were identified, suggesting that the demands placed on judo athletes in a contest differ across weight divisions and sexes. Another study by Xu et al. aimed to determine the differences in kinematic parameters associated with cross and uppercut punches between Sanda athletes and Boxing athletes and to analyse their impacts on peak punching speed. The punches from both groups of athletes were compared in terms of 13 key parameters utilizing a three-dimensional framework and high-speed cameras. The results revealed significant differences in six cross-related parameters and four uppercut-related parameters. Incognito et al. examined the role of the opponent's head in predicting the target of a kicking action in martial arts. A sample of mixed combat athletes and non-athletes watched a series of video clips depicting various kicking techniques with differing levels of spatial occlusion of the head, with no significant effect of expertise on

accuracy. Head occlusion did not significantly influence performance nor did it interact with expertise, suggesting that head and face information did not play a role in predicting opponent action intent.

Another aspect of combat sports extensively investigated in this special issue is physiological. A group of authors (Sek et al.) conducted a study aimed to determine the weight loss methods used before an official championship and their effects on the performance of wrestlers. Data from the sample of 350 competitive wrestlers were collected using the Athlete Weight Loss Methodology and Effects Scale and a personal information form. It was determined that wrestlers preferred weight-loss methods such as restricting food and fluids, using a sauna, and jogging with a raincoat. The mini review by Levy et al. also explores the psychological factors associated with weight-cutting practices among combat sports athletes. The authors concluded that implementing gradual weight loss strategies in combat sports may offer numerous advantages, but that education of the sport staff is necessary. One study (Nema et al.) dealt with both performance and physiological parameters in combat sports. The objective of this study was to assess the relationship between selected performance indicators of aerobic and anaerobic capacity to sports performance in elite karatekas. The Karate Specific Aerobic Test and the Wingate Test were applied to measure aerobic and anaerobic endurance while technical and tactical indicators were used to assess the level of athletic skill during competition. The high predictive validity confirmed the importance of a high level of anaerobic conditions for performance in karate.

Psychology, as an important factor in sport success, is also covered in this special issue. Neuropsychological impact of Sanda training on athletes' attention was investigated by Teng et al. The Attention Network Test was administered to a sample of professional Sanda athletes and a control group to compare differences in the efficiency of the alerting, orienting, and executive control networks. Compared to the control group, the Sanda athletes exhibited significant efficiency in the higher executive control network and the executive control network. Additionally, Piepiora et al. in their study emphasised the importance of mental preparation for kata competitors in karate, processing the specificity and methods of mental training.

Finally, the special issue includes studies that were concerned with the socio-cultural aspect of combat sports. Li et al. investigated gender equality, that is, the involvement of Chinese women in combat sports. Not only did the authors reveal that Chinese women still faced numerous restrictions in combat

sports, but they also presented the factors which may lead to this phenomenon and proposed several possible solutions for the problem. Authors Cheng and Guo implemented the educational ethnography method to explore curriculum content construction to ensure the inheritance of martial arts as intangible cultural heritage at universities. In the process, the emphasis is placed on local knowledge, core skills, cultural traditions, and other characteristics that highlight the excellence of the cultural heritage of martial arts. Santanna and Li conducted the study that explores the formation of a hybrid body image among white cisgender males practicing Wushu at the Siberian Chinese Martial Arts Center, in which narrative interviews with 12 participants were conducted and three main themes were revealed by thematic analysis.

Hopefully, the presented studies will contribute to further the understanding and development of combat sports and prove useful for future research in this field.

## Author contributions

LT: Writing – original draft, Writing – review & editing.

## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.



## OPEN ACCESS

## EDITED BY

Rafael Kons,  
Federal University of Bahia (UFBA), Brazil

## REVIEWED BY

Jozef Simenko,  
University of Ljubljana, Slovenia  
Gennaro Apollaro,  
University of Genoa, Italy

## \*CORRESPONDENCE

Luis Santos  
✉ lsanr@unileon.es

RECEIVED 17 January 2024

ACCEPTED 22 February 2024

PUBLISHED 11 March 2024

## CITATION

Santos L, Federolf PA, Schneider F, Pocco E, Fernández-Río J, Iglesias-Soler E, Carballeira-Fernández E, Uriarte S and Dopico-Calvo X (2024) In-contest body acceleration profiles for the judo male and female weight divisions. *Front. Sports Act. Living* 6:1372314. doi: 10.3389/fspor.2024.1372314

## COPYRIGHT

© 2024 Santos, Federolf, Schneider, Pocco, Fernández-Río, Iglesias-Soler, Carballeira-Fernández, Uriarte and Dopico-Calvo. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# In-contest body acceleration profiles for the judo male and female weight divisions

Luis Santos<sup>1,2\*</sup> , Peter A. Federolf<sup>3</sup> , Friedemann Schneider<sup>4</sup> , Elena Pocco<sup>3</sup> , Javier Fernández-Río<sup>5</sup> , Eliseo Iglesias-Soler<sup>2</sup> , Eduardo Carballeira-Fernández<sup>2</sup> , Sugoi Uriarte<sup>6</sup> and Xurxo Dopico-Calvo<sup>2</sup>

<sup>1</sup>University of León, Department of Physical Education and Sport, León, Spain, <sup>2</sup>Performance and Health Group, Department of Physical Education and Sport, University of A Coruña, A Coruña, Spain, <sup>3</sup>Department of Sport Science, University of Innsbruck, Innsbruck, Austria, <sup>4</sup>Department of Orthopedics and Traumatology, Medical University of Innsbruck, Innsbruck, Austria, <sup>5</sup>Department of Educational Sciences, University of Oviedo, Oviedo, Spain, <sup>6</sup>Doctorate School, Universitat Politècnica de València, Valencia, Spain

**Introduction:** This study aimed to determine the body accelerations (BA) profile of the judo contest of the male and female weight divisions and to ascertain the involvement of the vertical, mediolateral and anteroposterior axes in it.

**Methods:** Forty-eight male and forty-eight female national and international level athletes (some of them medalists in World, European and national championships) participated in a 5-min simulated contest (official fight time plus breaks) against an opponent of the same sex and weight division, wearing an accelerometer. Heart rate, blood lactate and ratings of perceived exertion were recorded to certify that the athletes performed the fullest.

**Results:** The t2way test expressed differences in the athletes' BA ( $p = 0.001$ ) and three profiles were identified: the light/middle weight male divisions, the light/middle weight female divisions and the heavy male and female ones. Athletes of all weight divisions performed their BA during the contest in all three directions (the one-sample Person's chi-square did not detect any significantly predominant one:  $p = 0.400$ ,  $p = 0.631$ ,  $p = 0.844$ ,  $p = 0.749$ ,  $p = 0.644$  and  $p = 0.895$ , for male light, moderate and heavy, female light, moderate and heavyweight athletes, respectively). Monte Carlo method simulations suggested as the most likely scenarios those with BA involving all axes, with a slight preference of the anteroposterior and mediolateral ones.

**Discussion:** These results suggest that the demands on judo athletes in a contest differ between weight classes and sexes.

## KEYWORDS

human motion assessment, physical activity's patterns, combat sports, mechanical parameters, training

## 1 Introduction

Judo is a Japanese martial art and an Olympic and Paralympic combat sport, introduced at the Tokyo Olympic Games in 1964 and the Seoul Olympic Games in 1988. Competitors obtain victory by throwing their opponents on their back from the standing position or by causing submission by neck choke, elbow armlock, or immobilization in ground combat (1). Contest involves open and complex skills, presents irregular intervals of effort and pause, and is characterized as an intermittent activity (2). The physiologic demands and employed metabolic mechanisms differ

substantially between the dynamic and calmer phases of the contest (3), leading to specific physiologic responses with specific implications for training and conditioning and for tactical preparation (4). Several previous studies [e.g., reviewed in Barreto et al. (5)] have analyzed the number of high-activity events or the duration of high-activity phases vs. calmer periods of contest. Such studies have generally been based on assessments of video materials with the subjective classifications of phases into high or low-activity classes. From these types of studies of any sport, several interesting concepts for training and competition have emerged. One of them is the “activity profile” (6–9). Overall, it refers to the individualized performance profiles of athletes through the analysis of the movement pattern that they express during competition.

Accelerometers can detect and record the body accelerations (BA) for motion along three orthogonal axes (vertical, mediolateral, and anteroposterior) in arbitrary acceleration units (a.u. or counts) (10). In this way, these devices provide a proxy measure of the mechanical work done by a moving body and wearable versions have been widely used to measure physical activity in clinical/laboratory and free-living environments (11). In combat sports, Kirk et al. (12) and Del Vecchio et al. (13) used wearable accelerometers to evaluate BA in a simulated mixed martial arts (MMA) contest and in several physical activities in a taekwondo training session (e.g., combat simulation, etc.), respectively. In addition, accelerometry has also been used in judo in the topics of injury prevention [e.g., (14–17)], and technique training [e.g. (18,19)]. However, as yet, there have been no studies quantifying in-contest BAs for judo athletes. This topic represents a potential area of exploration that would provide a valuable resource to objectively determine numerous dynamic aspects of this sport and provide a wealth of unknown information concerning the mechanical parameters of judo contestants that, alongside physiological data, might be incorporated into training programs. Of course, judo competitions are organized based on sex and weight categories, and competitors across distinct weight classes exhibit variations in technical and tactical aspects, as well as in physiology, performance, and body composition (20–22). Thus, to ensure that the fullest, most detailed picture is obtained, and for the BA data to be applied accurately, the quantification in-contest BAs for judo athletes must also be specified according to these categories.

Thus, the goals of this study were to determine the BAs profile of the male and female weight divisions in a judo contest and to ascertain the involvement of the vertical, mediolateral, and anteroposterior axes in it, in a sample of national and international level judo athletes. It was hypothesized that two different BA profiles of the judo contest would be identified: the male and female athletes of the light and middle weight divisions and the male and female ones of the heavy weight divisions. It was also expected that athletes of all weight divisions would mainly express their BA during the contest in the anteroposterior and the vertical axes, with the BA of the anteroposterior axis being the significantly predominant one.

## 2 Material and methods

### 2.1 Design

This descriptive study was designed in accordance with the updated Declaration of Helsinki. The study protocol was approved by the Research Ethics Committee of the Principality of Asturias, Spain (No. 287/19), by the Board for Ethical Issues of the University of Innsbruck, Austria (No. 51/2019), and by the Research Ethics Committee of the University of Erlangen-Nürnberg, Germany (No. 421\_19 B).

### 2.2 Participants

The study's sample size was determined through a calculation of Cohen's statistical power analysis for the analysis of variance (ANOVA) designs (23). This process was performed using R software ([www.r-project.org](http://www.r-project.org), version 3.3.1., 2016.06.21), setting an effect size (Cohen's  $f$ ) of 0.40 and a power of 0.85. The resulting sample size was 16 participants in each group (six groups in total).

Thus, ninety-six judo athletes (average age of  $22.8 \pm 3.7$  years, a height of  $175.1 \pm 10.7$  cm, a body weight of  $76.3 \pm 17.4$  kg, and a coefficient of variation [CV] of body weight of  $7.8 \pm 2.8\%$ ), comprising forty-eight men and forty-eight women at national and international levels, hailing from Spain, Austria, Germany, Italy, Denmark, Georgia, the Dominican Republic, Venezuela, Ukraine, and Puerto Rico, actively participated in this project. Among them were accomplished medalists from World, European, and National championships, as well as various international tournaments. The athletes of the sample were clustered on six groups, considering the official weight divisions: lightweight ([ML]; <60 kg, <66 kg, <73 kg), middleweight ([MM]; <81 kg, <90 kg) and heavyweight ([MH]; <100 kg, >100 kg) for males, and lightweight ([FL]; <48 kg, <52 kg, <57 kg), middleweight ([FM]; <63 kg, <70 kg) and heavyweight ([FH]; <78 kg, >78 kg) for females. The athletes' body weight and height assessment was carried out with a medical scale equipped with moving weights and a stadiometer.

The recruitment phase for the study extended from September 2019 to December 2019, while data collection occurred between January 2020 and September 2022. All participants provided informed written consent. Inclusion criteria stipulated that athletes had to be active adults ( $\geq 18$  years) competing at the national or international level for a minimum of four consecutive years, and free from any musculoskeletal injury or disease that could impede study completion. Overall, the competitors' weekly training programs included five to six sessions. Three to four sessions focused on technical-tactical training, while two to three emphasized conditioning, encompassing both gym-based and mat-based activities. Typically lasting two to two and a half hours, training occurred regularly for eleven months each year. At the time of the project, participants were in the preparatory phase of their training programs, with no individuals undergoing rapid weight loss. They were instructed not to use alcohol or any

other drug for at least 24 h before the evaluations and to maintain their habitual diet. Characteristics of the participants are shown in [Table 1](#).

### 2.3 Procedures

Athletes participated in one simulated contest (with standing and ground judo), which was managed according to the official competition rules, against an opponent of the same sex and official weight division wearing accelerometers, and they were instructed to perform to their fullest during it. In order to detect the primary behavioral patterns of the assessed variables in the study (the athletes' BA in the judo contest and the involvement of the vertical, mediolateral, and anteroposterior axes) an extended duration for the contest was selected. Considering that a typical judo contest is a sequence of 20–30 s effort periods interspersed with 10 s breaks (4) over 4 min (breaks excluded), resulting in a total fight time of 4.5 to 5 min, the contest time for this study was set at 5 min. To ensure a precise 5-min duration for every contest, a special rule was applied; specifically, if a participant scored an *ippon* (which concludes the contest), the contest would be restarted and allowed to continue until 5 min had elapsed. Data obtained during the contest breaks were also included in the accelerometric data for the judo contest, as they were considered to express their specific background. Nonetheless, if breaks of any contests exceeded the usual break time of the judo contests [10 s (4)], these contests were considered invalid for the analysis. National/international referees judged all contests.

The accelerometers worn by athletes were located over their belly buttons, just under the knot of their judo belt, and secured using an adjustable elastic belt. This position was chosen for two reasons. Firstly, it carried the least risk of injury for athletes.

Secondly, it is close to the athlete's center of gravity. Due to the nature of judo motricity, particularly the large number of asymmetric moves involved, placing the accelerometer in a location displaced from the center of gravity would potentially produce misleading, unbalanced data. The device was mounted with its vertical axis pointing upwards, such that its inclinometer was maintained in a vertical position throughout every contest (24). The accelerometers were programmed to begin collecting data two minutes before the start of a contest with data saved in 20-min files. Additionally, heart rate (HR) was monitored during the contest and ratings of perceived exertion [RPE, Borg 6–20 scale (25)] at the end. Blood lactate (BLa) was also obtained 1 min after the end of the contest [since judo athletes express the highest BLa concentration after a contest at this time (26)], to certify that the athletes performed to their fullest and that the study's contests would produce valid data for the scientific literature.

#### 2.3.1 Accelerometry

ActiGraph GT3X accelerometers (ActiGraph™, Pensacola, FL, USA), which have been shown to be reliable (27), sampling at 30 Hz, were employed. They use a solid-state tri-axial accelerometer to collect motion data on three axes (vertical, mediolateral, and anteroposterior). Acceleration magnitudes were registered as a.u./counts and processed according to the Freedson's algorithm for adults (28). Given the explosive nature of the judo contest, the scoring reports obtained were edited as follow: 3-sec epoch length for axes. The BA of the contest were collected from the accelerometers as vector magnitude (Vector Magnitude CPM, in the software of ActiGraph), the equation of which is this:  $VM = \sqrt{(x^2 + y^2 + z^2)}$ . It is presented in a.u./counts per min (cpm). BA along the three axes were also collected during the contest (axis 1-vertical- CPM, axis 2 -mediolateral-

TABLE 1 Characteristics of the participants.

Outcomes	Male (n = 48)			Female (n = 48)		
	Light weight (n = 16)	Middle weight (n = 16)	Heavy weight (n = 16)	Light weight (n = 16)	Middle weight (n = 16)	Heavy weight (n = 16)
Age (years)	22 ± 3	26 ± 6	24 ± 4	22 ± 2	22 ± 3	23 ± 2
Height (cm)	174.5 ± 5.5	181.7 ± 5.3	188.5 ± 5.5	157.6 ± 4.5	171.5 ± 4	177.2 ± 3.5
Body weight (kg)	67.9 ± 5.9	84.9 ± 3.9	103.3 ± 10.6	51.9 ± 3.7	67.1 ± 3.3	82.4 ± 9.3
CV of the body weight (%)	8.6	4.6	10.3	7.1	4.9	11.3
Official weight division <sup>a</sup>	4 from <60 kg/5 from <66 kg/7 from <73 kg	9 from <81 kg/7 from <90 kg	7 from <100 kg/9 from >100 kg	6 from <48 kg/5 from <52 kg/5 from <57 kg	7 from <63 kg/9 from <70 kg	7 from <78 kg/9 from >78 kg
Nationality <sup>a</sup>	3 AUT/3 GER/8 ESP/2 VEN	5 AUT/6 GER/4 ESP/1 GEO	3 AUT/7 GER/5 ESP/1 GEO	6 AUT/8 ESP/ 2 ITA	3 AUT/2 GER/5 ESP/2 DEN/ 2 DOM/1 PUR/1 UKR	6 AUT/2 GER/4 ESP/ 2 ITA/2 DOM
Judo degree <sup>a</sup>	11 1 <sup>st</sup> dan/4 2nd dan/1 3rd dan	6 1 <sup>st</sup> dan/7 2nd dan/3 3rd dan	5 1 <sup>st</sup> dan/9 2nd dan/2 3rd dan	6 1 <sup>st</sup> dan/10 2nd dan	10 1 <sup>st</sup> dan/5 2nd dan/1 3rd dan	6 1 <sup>st</sup> dan/9 2nd dan/ 1 3rd dan
Performance level <sup>a</sup>	7 Nat/9 Int	9 Nat/7 Int	10 Nat/6 Int	8 Nat/8 Int	6 Nat/10 Int	11 Nat/5 Int

All values are presented as a mean and standard deviation unless otherwise stated.  
CV, coefficient of variation; AUT, Austria; GER, Germany; ESP, Spain; VEN, Venezuela; GEO, Georgia; ITA, Italy; DEN, Denmark; DOM, Dominican Republic; PUR, Puerto Rico; UKR, Ukraine; Nat, national; Int, International.  
<sup>a</sup>Number of athletes in each weight division, nationality, judo degree and performance level, respectively.



CPM, and axis 3 -anteroposterior- CPM in the software) and are also presented in a.u./cpm and as a percentage.

### 2.3.2 HR

HR was recorded using a HR monitor (Polar S810, OY, Oulu, Finland) with a chest strap. Data were expressed in beats per min (b/min) and as a percentage of the individual maximal HR (% HRmax). HRmax was calculated using this formula:  $[\text{HRmax} = 208 \text{ b/min} - (0.7 \times \text{age in years})]$  (29).

### 2.3.3 BLa

Micro-samples of arterialized blood were obtained by puncturing the earlobe to determine BLa concentrations. They were analyzed with the Lactate Pro II analyzer (Akray-KDK, Koka, Japan). Two errors occurred during BLa data acquisition: one for an athlete in the FM division and another for an athlete in the FL division.

### 2.3.4 RPE

The Borg 6–20 RPE scale was used to determine the athletes' perceived exertion effort (25). The scale was explained to all participants prior to the beginning of the data collection.

## 2.4 Statistical analysis

All values are shown as means and standard deviations unless otherwise indicated. The normality and homoscedasticity of the data were evaluated using the Shapiro-Wilks and Bartlett's tests, respectively ( $p > 0.05$ ). Given that they were not verified in any dependent variable, the robust t2way test (30) was performed to assess differences among all athletes' groups, using sex (male and female) and weight (light, middle, and heavy) as factors. The robust Lincon test was used to determine the between-group differences ( $p < 0.05$ ). When significant differences were detected in the dependent variables, effect size was calculated to determine the magnitude of differences. Rosenthal's  $r$  was used (where  $r = Z/\sqrt{N}$  and "Z" value was obtained from the Exact Wilcoxon-Mann-Whitney test) and defined as small ( $r > 0.20$ ), moderate ( $r > 0.50$ ), or great ( $r > 0.80$ ) (31). One-sample Pearson's chi-squared ( $\chi^2$ ) test was used to evaluate the over- or under- representation of the BA of the three axes in the judo contest, with the a.u./cpm values expressed as percentages (to determine if any axis was significantly predominant in the contest) ( $p < 0.05$ ). Finally, the Monte Carlo method, which simulates real sceneries and their probabilities (32), was carried out since the Pearson's chi-squared ( $\chi^2$ ) test did not detect any significant predominant axis in the contest. Thereto, 30.000 contest simulations were carried out (10.000 for each of the vertical, mediolateral, and anteroposterior axes) in each weight division, to estimate the behavior of the motion data of the contest on three axes. It was done using a Poisson distribution with the means -as percentages- of the motion data of the contest on three axes obtained in this study. Three scenarios (and their probabilities of happening) were calculated for each axis in all divisions aiming to simulate situations corresponding

to the median and the upper and lower values of the 95% confidence interval of each data distribution. All data were analyzed using R software.

## 3 Results

With respect to the BA, a significant sex-by-weight interaction was found (Table 2), with the highest BA score found for the ML category. The highest BA value for women was recorded for the FL category, this being slightly higher than the lowest male value. Large and statistically significant differences were found between BAs for ML and MH ( $p < 0.001$ ,  $r = 0.73$ , moderate effect), MM and MH ( $p < 0.001$ ,  $r = 0.73$ , moderate effect), FL and FH ( $p < 0.001$ ,  $r = 0.68$ , moderate effect), and FM and FH ( $p = 0.003$ ,  $r = 0.61$ , moderate effect) (Table 2, Figure 1).

Regarding the involvement of the three axes, a significant sex-by-weight interaction was observed for the anteroposterior axis (Table 2). Athletes of all weight divisions mainly performed their BA in the anteroposterior and the mediolateral axes, with athletes of both sexes in the light and middle weight divisions having higher BA values than those in the heavy division (Table 2, Figure 2). Differences among weight divisions in the three axes were also observed. However, the one-sample Pearson's chi-squared ( $\chi^2$ ) test did not show any of the axes to be significantly predominant in any weight division during the contest ( $p = 0.400$ ,  $p = 0.631$ ,  $p = 0.844$ ,  $p = 0.749$ ,  $p = 0.644$ , and  $p = 0.895$ , for ML, MM, MH, FL, FM, and FH, respectively). The Monte Carlo method suggested the scenarios with BA involving all axes as the most likely, with a slight preference of the anteroposterior and mediolateral ones, across all weight divisions for both sexes (Table 3). Thus, scenarios in which BA shows a clearly dominant axis appear to have only a marginal probability of occurrence (Table 3).

Concerning physiological variables, the HR at the end of the contest did not manifest a significant difference among the weight divisions, the % HRmax at the end of the contest presented one significant difference between the ML and FH ( $p < 0.001$ ,  $r = 0.59$ , moderate effect), the BLa 1 min after the end of the contest also showed several significant differences (MM vs. FM,  $p = 0.043$ ,  $r = 0.46$ , moderate effect; MM vs. FH,  $p = 0.009$ ,  $r = 0.55$ , moderate effect; MH vs. FL,  $p < 0.001$ ,  $r = 0.73$ , moderate effect; MH vs. FH,  $p < 0.008$ ,  $r = 0.56$ , moderate effect), and the RPE at the end of the contest did not display significant differences (Table 2).

## 4 Discussion

The goals of this study were to determine the BA profile of the judo contest of the male and female weight divisions and to ascertain the involvement of the vertical, mediolateral and anteroposterior axes in it. Results allow the identification of three BA profiles in judo; one for ML and MM, another one for FL and FM and the third one for MH and FH. In relation to the axes' involvement, findings revealed that athletes of all weight

TABLE 2 Accelerometric and physiological data of the judo contest.

Outcomes	Male			Female			Stats ( <i>p</i> -values)			Effect Size ( <i>r</i> )
	Light Weight (ML)	Middle Weight (MM)	Heavy Weight (MH)	Light Weight (FL)	Middle Weight (FM)	Heavy Weight (FH)	Sex Effect	Weight Effect	Sex by weight Effect	
BA (a.u./cpm) <sup>a</sup>	9,075.5 ± 915.4	8,970.3 ± 791.3	7,519.6 ± 478.6	7,908.6 ± 354.7	7,894.7 ± 497.7	7,240.3 ± 411.7	<b>0.001</b>	<b>0.001</b>	<b>0.004</b>	ML vs. MH, <i>r</i> = 0.73 ML vs. FL, <i>r</i> = 0.62 ML vs. FM, <i>r</i> = 0.60 ML vs. FH, <i>r</i> = 0.80 MM vs. MH, <i>r</i> = 0.73 MM vs. FL, <i>r</i> = 0.66 MM vs. FM, <i>r</i> = 0.59 MM vs. FH, <i>r</i> = 0.81 MH vs. FL, <i>r</i> = 0.42 FL vs. FH, <i>r</i> = 0.68 FM vs. FH, <i>r</i> = 0.61
BA Vertical Axis [a.u./cpm <sup>a</sup> (%)]	4,588.2 ± 1,028.1 (29.3 ± 4.3)	4,672.1 ± 539.7 (30.2 ± 1.7)	3,985.4 ± 387.2 (30.8 ± 2.4)	4,180.9 ± 316.9 (30.5 ± 2.3)	4,249.2 ± 529.7 (31.4 ± 2.5)	3,982.1 ± 523.9 (31.5 ± 2.5)	<b>0.039</b>	<b>0.002</b>	0.407	MM vs. MH, <i>r</i> = 0.66 MM vs. FL, <i>r</i> = 0.44 MM vs. FH, <i>r</i> = 0.59
BA Mediolateral Axis [a.u./cpm <sup>a</sup> (%)]	4,786.5 ± 522.3 (31.1 ± 3.5)	4,946.7 ± 459.5 (32.1 ± 1)	4,361.3 ± 367.8 (33.7 ± 2.1)	4,455.2 ± 209.3 (32.6 ± 1.4)	4,583.9 ± 358.5 (33.7 ± 1.7)	4,116.7 ± 305.2 (33.2 ± 1.6)	<b>0.001</b>	<b>0.001</b>	0.219	ML vs. MH, <i>r</i> = 0.44 ML vs. FH, <i>r</i> = 0.57 MM vs. MH, <i>r</i> = 0.58 MM vs. FL, <i>r</i> = 0.58 MM vs. FH, <i>r</i> = 0.73 FL vs. FH, <i>r</i> = 0.62 FM vs. FH, <i>r</i> = 0.67
BA Anteroposterior Axis [a.u./cpm <sup>a</sup> (%)]	6,137.9 ± 591.2 (39.6 ± 2.2)	5,828.9 ± 573.2 (37.7 ± 2.1)	4,606.4 ± 364.8 (35.5 ± 1.2)	5,061.6 ± 367.2 (36.9 ± 1.8)	4,725.3 ± 247.8 (34.9 ± 1.7)	4,402.1 ± 327.3 (35.3 ± 3.1)	<b>0.001</b>	<b>0.001</b>	<b>0.001</b>	ML vs. MH, <i>r</i> = 0.83 ML vs. FL, <i>r</i> = 0.73 ML vs. FM, <i>r</i> = 0.83 ML vs. FH, <i>r</i> = 0.84 MM vs. MH, <i>r</i> = 0.80 MM vs. FL, <i>r</i> = 0.63 MM vs. FM, <i>r</i> = 0.82 MM vs. FH, <i>r</i> = 0.83 MH vs. FL, <i>r</i> = 0.55 FL vs. FM, <i>r</i> = 0.43 FL vs. FH, <i>r</i> = 0.73 FM vs. FH, <i>r</i> = 0.53
Maximum HR measured in the contest (b/min) <sup>a</sup>	170 ± 9	173 ± 14	177 ± 14	177 ± 13	180 ± 12	182 ± 5	<b>0.021</b>	0.097	0.303	—
Maximum HR measured in the contest as % HRmax (%) <sup>a</sup>	88 ± 5	91 ± 7	92 ± 7	92 ± 6	93 ± 7	95 ± 3	0.059	<b>0.038</b>	0.331	ML vs. FH, <i>r</i> = 0.59
BLa 1 min after the end of the contest (mmol/L) <sup>a</sup>	11.8 ± 3.1	14.3 ± 4.1	12.4 ± 2.5	8.9 ± 1.8	10.6 ± 3.1	10.2 ± 1.6	<b>0.001</b>	<b>0.011</b>	0.250	MM vs. FM, <i>r</i> = 0.46 MM vs. FH, <i>r</i> = 0.55 MH vs. FL, <i>r</i> = 0.73 MH vs. FH, <i>r</i> = 0.56
RPE at the end of the contest (a.u.) <sup>a</sup>	15.9 ± 2.1	16.7 ± 1.8	17.1 ± 1.4	16.6 ± 1.9	16.7 ± 2.5	17.8 ± 1.5	0.269	0.529	0.971	—

All values are presented as a mean and standard deviation unless otherwise stated.

BA, body accelerations; a.u./cpm, arbitrary units-counts per min; HR, heart rate; % HRmax, percentage of individual maximal HR; BLa, blood lactate; RPE, ratings of perceived exertion.

BLa values represents 94 data points (two errors occurred; one in the female lightweight group and another in the female middleweight).

<sup>a</sup>Robust statistical/method assessments used. Roshentals *r* effect size.

Bold values express significant differences (*p* < 0.05).

divisions tend not to favor any particular axis during the contest, since all of them are almost equally involved. The Monte Carlo method simulations suggested as the most likely scenarios those with BA involving all axes, with a slight preference of the anteroposterior and mediolateral ones.

The hypothesis that two different BA profiles of the judo contest would be identified was not confirmed; three different BA profiles were detected. To date, no study has determined the BA of the judo male and female contests. Kirk et al. (12) determined the external load experienced by the MMA athletes

during a simulated MMA contest comprising three rounds of 5 min with 1 min rest between rounds, from the magnitudes of accelerations in the mediolateral, vertical and anteroposterior axes (224.32 ± 26.59 a.u./counts). External load or load are the concepts used in Sports Sciences to refer to the BA (reported as a.u./counts) of a specific physical activity. In the study of Kirk et al. (8), athletes wore Minimax X3, triaxial accelerometers secured to the torso using in a neoprene harness over the T3–4 vertebrae (the epoch configuration was not specified). Del Vecchio et al. (13) determined the BA of a



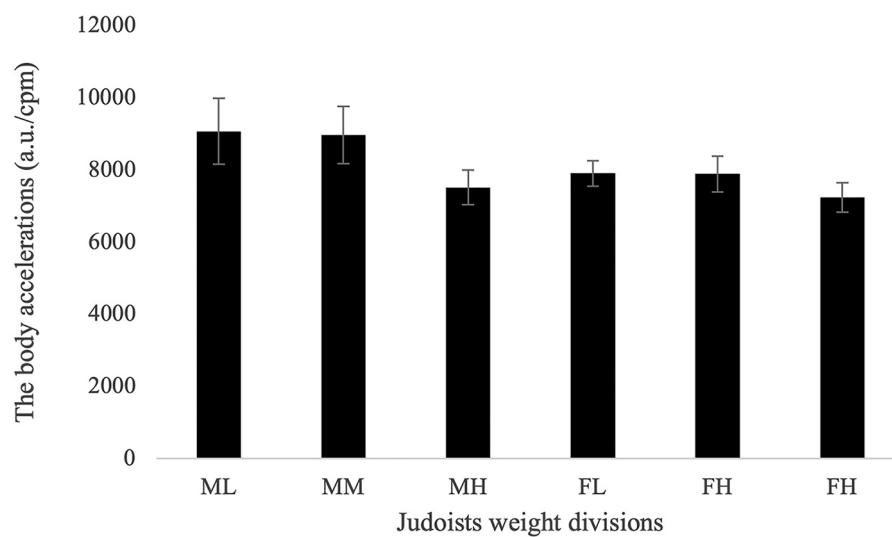


FIGURE 1

The body accelerations expressed by the whole judo weight divisions in the contest. All values are presented as a mean and standard deviation unless otherwise stated. a.u./cpm, arbitrary units-counts per min; ML, male lightweight; MM, male middleweight; MH, male heavyweight; FL, female lightweight; FM, female middleweight; FH, female heavyweight.

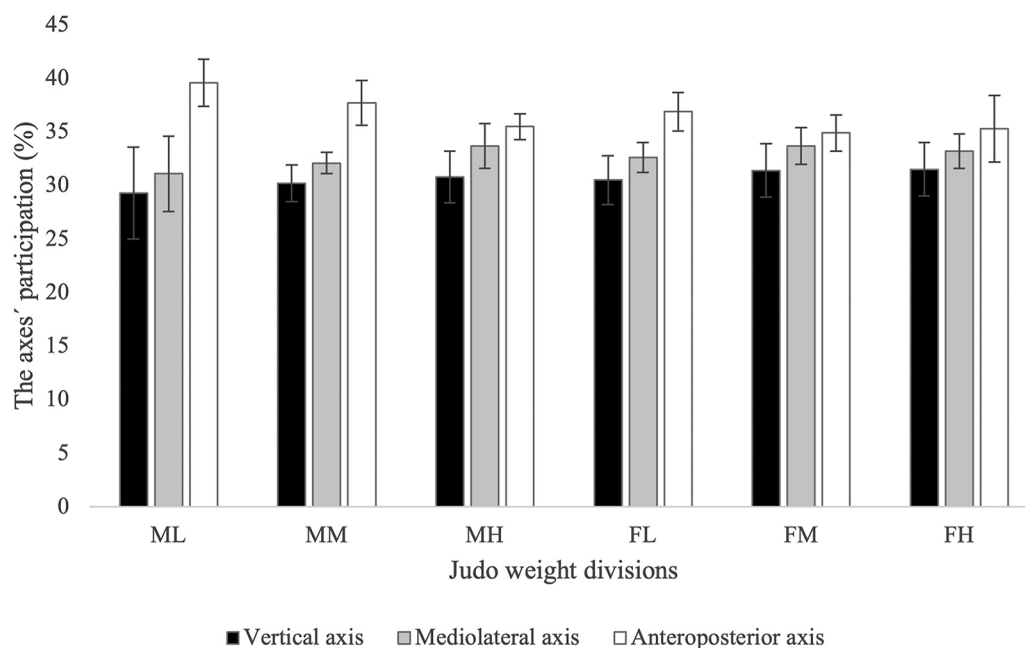


FIGURE 2

The percentage participation of the axes in the judo contest of the whole judo weight divisions. All values are presented as a mean and standard deviation unless otherwise stated. ML, male lightweight; MM, male middleweight; MH, male heavyweight; FL, female lightweight; FM, female middleweight; FH, female heavyweight.

sample of non-adult taekwondo athletes (expressed as VM) in several physical activities, in a taekwondo training session (e.g., combat simulation, etc.). They used an ActiGraph wGT3X+ device that was located on at the waist of the athletes, with a 5-epoch configuration and with the Freedson's algorithm for

children (33) to process data and their result in the contest simulation was a BA of  $530.44 \pm 240.42$  a.u./cpm. Given the underlying mechanisms driving the differences of BA between light, middleweight, and heavy divisions and between sexes found in the present study, they remain unknown. Thus,

TABLE 3 Results of the monte carlo simulations for the axes' participation in the judo contest.

Axes	Possible scenario	ML (Male lightweight)	MM (Male middleweight)	MH (Male heavyweight)	FL (Female lightweight)	FM (Female middleweight)	FH (Female heavyweight)
Vertical	Upper (probability)	40% (2.3%)	41% (2.4%)	42% (2.2%)	42% (1.9%)	43% (1.9%)	43% (2%)
	Median (probability)	29% (47.4%)	30% (46.5%)	30% (51.5%)	30% (48.9%)	31% (47.8%)	31% (49%)
	Lower (probability)	19% (2.8%)	20% (3.2%)	20% (2.5%)	20% (2.9%)	21% (3.3%)	21% (3.1%)
Mediolateral	Upper (probability)	41% (2.3%)	44% (1.8%)	46% (1.7%)	44% (2.3%)	45% (2.5%)	45% (1.9%)
	Median (probability)	31% (45.2%)	32% (45.9%)	34% (43.4%)	32% (49.5%)	33% (50.1%)	33% (45.7%)
	Lower (probability)	21% (3.7%)	21% (2.5%)	23% (3.4%)	22% (3.3%)	23% (3.3%)	22% (2.8%)
Anteroposterior	Upper (probability)	52% (2.3%)	51% (1.6%)	48% (1.8%)	44% (2%)	47% (2%)	47% (2.4%)
	Median (probability)	39% (49.2%)	37% (51%)	35% (48.6%)	36% (49.5%)	35% (44.4%)	35% (47.6%)
	Lower (probability)	28% (3.4%)	26% (2.7%)	24% (2.7%)	25% (2.8%)	24% (3.4%)	24% (2.9%)

Each table cell shows the values of the axis participation expressed as percentage (and its probability of happening as percentage in brackets). The upper and lower probability scenarios correspond to the upper and lower bounds of the 95% confidence interval of the observed data distribution.

further research is needed to ascertain the factors contributing to these phenomena. However, these results suggest firstly, that weight affects the dynamics of the contest and secondly, that the way it influences the dynamics of the contest varies between sexes. A study by Sterkowicz-Przybycień et al. (21) with elite judo athletes, found significant differences in combat-phase times dependent on weight category and sex divisions. Additionally, in a study of male and female judo cadets, Miarka et al. (34) identified sex differences in the frequencies and timings of judo combat actions, types of techniques used, and numbers of penalties received. Thus, it seems likely that the strategic priorities in judo differ across weight divisions and between the sexes and this goes some way to explaining the results of the present study.

About the contribution of three axes in the judo contests, the hypothesis that athletes of all weight divisions would mainly express their BA during the contest in the anteroposterior and the vertical axes, being the BA of the anteroposterior axis the significantly predominant one, was not confirmed; athletes of all sexes and weight divisions produced BA on all axes equally. This finding should be considered in the design of training programs. To the authors' knowledge, the current literature contains no studies examining the issue of BA directional demands in judo contests. Santos et al. (36) evaluated the effects of judo contest on the athletes' postural control and physiological loading before, during and after a simulated contest. They observed the greatest effects manifested on the anteroposterior axis, which is not in accordance with this study. Here again, the core processes behind these outcomes remain undiscovered; therefore, additional investigation is necessary to identify their determinants. Regarding the results of the study of Santos et al. (35) and those of the Monte Carlo method of this study, the dominant trend in the contest could be that the anteroposterior axis could have a slightly higher participation than the rest axes. Nevertheless, this tendency might vary during specific contest moments (e.g., when

an athlete is guarding an advantage, emphasizing the mediolateral axis).

All physiological variables examined here are in line with results from previous studies. This suggests that the athletes who participated in this study did indeed perform to their fullest abilities during the study's contests and thus, the analysis of these contests provides a useful contribution to the scientific literature. For instance, the maximum HR measured during the contests in this work were between  $170 \pm 9$  and  $182 \pm 5$  b/min ( $88.4 \pm 5.2$  and  $94.7 \pm 2.9\%$  of the HRmax), which compares favorably with values measured by Sbriccoli et al. (36) in senior male and female judo athletes, respectively, in simulated contests [ $181 \pm 11$  b/min (94.8% of HRmax) and  $176 \pm 6$  (92.87% of HRmax)]. Similarly, the BLA values seen in this study (from  $8.9 \pm 1.8$  to  $14.3 \pm 4.1$  mmol/L) are also in agreement with previous research which, after simulated judo contests are reported as being from  $7.5 \pm 5.1$  to  $18.1 \pm 4.4$  mmol/L (37, 38). Lastly, end-of-contest RPE, which in this study is recorded as from  $15.9 \pm 2.1$  to  $17.8 \pm 1.5$  a.u. is also in the same range as the value for this variable seen in other research. For example, Chtourou et al. (39) obtained values between 14 and 14.5 a.u. for regional and national level athletes after a 5-min simulated judo contest; Stavrinou et al. (40) reported  $19.1 \pm 0.78$  a.u. in cadets after the last of a set of four 4-min contests; and Santos et al. (35) recorded  $16.1 \pm 0.4$  a.u. for regional and national athletes after a 7-min simulated judo contest.

## 4.1 Limitations

The present study has several limitations. Firstly, there are seven weight categories for each sex, while athletes of the present study were grouped in three for each sex, to avoid too small subgroup sizes and to achieve a higher control over the

results. Thus, the accelerometric data of specific weight divisions might be not exactly the same than those of the present study. However, in the case that these differences existed, due to the sample size of this study, they would not be significant and hence, it can be considered that the present study's results express the real background of the whole specific weight divisions. Secondly, in this study, a large duration of the contest was employed since, it was aimed to detect the primary pattern of behavior of the variables under assessment. To conduct a more comprehensive analysis of the variables' behavior, future studies should consider both shorter and longer durations for the contest. And thirdly, the current study's data were collected in simulation contests. BLa values are approximately 3 mmol/L higher in real competitions than in simulations (4). Nevertheless, the current study's results of this parameter are in accordance with those of the previous ones, hence they can be considered as valid.

## 4.2 Practical applications

The results of the present study can be interpreted and applied to the training of judo athletes. Firstly, the three BA profiles presented provide a benchmark for athletes. As the BA data are presented in cpm, coaches can utilize accelerometers to measure the athlete's BA in any kind of training task (regardless its duration) and subsequently, they will be able to determine how close or far athletes were from the production of BA of a specific weight division. Secondly, coaches can also use accelerometers to identify the axes which athletes perform any kind of training task, and to design training tasks focused on; executing the special techniques (*tokui-waza*) of the athletes in a specific axis (e.g., predominantly in the mediolateral or the anteroposterior one) or on staying predominantly in a specific axis to maintain an advantage and avoid penalties (e.g., in the mediolateral axis), under the symmetrical and asymmetrical grip (*aiyotsu* and *kenka-yotsu*, respectively) conditions. Finally, not only does this study offer new opportunities to improve and personalize judo training by the incorporation of a readily-measurable mechanical parameter but it also demonstrates an application of Monte Carlo simulation methods in Sports Science.

Future studies related to the BA's profile of judo contests in the male and female weight divisions, as well as the involvement of the vertical, mediolateral, and anteroposterior axes, should assess the effect of technical/tactical and strength and conditioning training programs on the findings of the present study (specifically, the three BA profiles and equal axes involvement in the contest). These studies will enable the optimization of training protocols and enhancement of athletes' performance in competition.

## 5 Conclusions

This study suggests that demands on judo athletes in a contest, measured in terms of body accelerations, differ by sex and weight classes with three different profiles; light and middle weight males, light and middle weight females, and heavy weight for both. Hence,

professionals should tailor the training regimens to accommodate these distinct profiles within the weight and gender classes. In addition, this study also suggests that judo contest motion data spans equally along the vertical, mediolateral and anteroposterior axes, with the most probably scenario of a slight preference of the anteroposterior and mediolateral axes. Thus, professionals should design training tasks which could enclose all these situations to better prepare athletes for the dynamics of contests.

## Data availability statement

The raw data supporting the conclusions of this article are available on request from the corresponding author.

## Ethics statement

This descriptive study was designed in accordance with the updated Declaration of Helsinki. The study protocol was approved by the Research Ethics Committee of the Principality of Asturias, Spain (No. 287/19), by the Board for Ethical Issues of the University of Innsbruck, Austria (No. 51/2019), and by the Research Ethics Committee of the University of Erlangen-Nürnberg, Germany (No. 421\_19 B). The participants provided their written informed consent to participate in this study.

## Author contributions

LS: Conceptualization, Formal Analysis, Supervision, Writing – original draft, Writing – review & editing. PF: Conceptualization, Formal Analysis, Writing – original draft, Writing – review & editing. FS: Conceptualization, Supervision, Writing – original draft, Writing – review & editing. EP: Conceptualization, Formal Analysis, Writing – original draft, Writing – review & editing. JF-R: Conceptualization, Formal Analysis, Writing – original draft, Writing – review & editing. EI-S: Conceptualization, Formal Analysis, Writing – original draft, Writing – review & editing. EC-F: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. SU: Conceptualization, Data curation, Writing – original draft, Writing – review & editing. XD-C: Conceptualization, Data curation, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Acknowledgments

The authors wish to thank the Masters and athletes at Takeda Gym (Oviedo, Spain), Blume Gym (Ponferrada, Spain), Judo Club Valencia (Valencia, Spain), Judozentrum (Innsbruck, Austria), Erlangen University Judo Club (Erlangen, Germany), Bronsoj Judo Club

(Copenhagen, Denmark), and those at many other Judo clubs who took part in this investigation for their commitment to this research project.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## References

- Pierantozzi E, Muroi R. Judo high level competitions injuries. *Medit J Musc Surv.* (2009) 17:26–9.
- Branco B, Massuca LM, Andreato MB, Monteiro L, Miarka B, Franchini E. Association between the rating perceived exertion, heart rate and blood lactate in successive judo fights (randori). *Asian J of Sports Med.* (2003) 4:125–30. doi: 10.5812/asjms.34494
- Degoutte F, Jouanel P, Filaire E. Energy demands during a judo match and recovery. *Br J Sports Med.* (2003) 37:245–49. doi: 10.1136/bjms.37.3.245
- Franchini E, Artioli GG, Brito CJ. Judo combat: time-motion analysis and physiology. *Int J Perform Anal Sport.* (2013) 13:624–41. doi: 10.1080/24748668.2013.11868676
- Barreto LBM, Santos MA, Fernandes Da Costa LO, Valenzuela D, Martins FJ, Slimani M, et al. Combat time in international male judo competitions: a systematic review and meta-analysis. *Front Psychol.* (2022) 8(13):817210. doi: 10.3389/fpsyg.2022.817210
- Bangsbo J, Nørregaard L, Thorsø F. Activity profile of competition soccer. *Can J Sport Sci.* (1991) 16(2):110–6.
- Makaje N, Ruangthai R, Arkarapanthu A, Yoopat P. Physiological demands and activity profiles during futsal match play according to competitive level. *J Sports Med Phys Fitness.* (2012) 52:366–74.
- Beato M, Coratella G, Schena F, Hulton AT. Evaluation of the external and internal workload in female futsal players. *Biol. Sport.* (2017) 34:227–31. doi: 10.5114/biolport.2017.65998
- Ribeiro JN, Gonçalves B, Coutinho D, Brito J, Sampaio J, Travassos B. Activity profile and physical performance of match play in elite futsal players. *Front. Psychol.* (2020) 11:1709. doi: 10.3389/fpsyg.2020.01709
- Bouten CVC, Koekkoek KTM, Verduin M, Kodde R, Janssen JD. A triaxial accelerometer and portable data processing unit for the assessment of daily physical activity. *IEEE Trans Biomed Eng.* (1997) 44(3):136–47. doi: 10.1109/10.554760
- Mathie MJ, Coster ACF, Lovell NH, Celler BG. Accelerometry: providing an integrated, practical method for long-term, ambulatory monitoring of human movement. *Physiol Meas.* (2004) 25:1–20. doi: 10.1088/0967-3334/25/2/r01
- Kirk C, Hurst HT, Atkins S. Measuring the workload of mixed martial arts using accelerometry time motion analysis and lactate. *Int J Perform Anal Sport.* (2015) 15(1):359–70. doi: 10.1080/24748668.2015.11868798
- Del Vecchio FB, Bartel C, Galliano LM, Fukuda DH. Accelerometry use to study external load in combat sports: an example from taekwondo. *J Phy Fit Treatment & Sports.* (2018) 3(2):555608.
- Murayama H, Hitosugi M, Motozawa Y, Ogino M, Koyama K. Rotational acceleration during head impact resulting from different judo throwing techniques. *Neurol Med Chir.* (2014) 54(5):374–8. doi: 10.2176/nmc.2013-0227
- Ishikawa Y, Anata K, Hayashi H, Yokoyama T, Ono T, Okada S. Effects of different throwing techniques in judo on rotational acceleration of uke's head. *Int J Sport Health Sci.* (2018) 16:173–9. doi: 10.5432/ijshs.201713
- Murayama H, Hitosugi M, Motozawa Y, Ogino M, Koyama K. Ukemi technique prevents the elevation of head acceleration of a person thrown by the judo technique 'Osoto-gari'. *Neurol Med Chir.* (2020) 60(6):307–12. doi: 10.2176/nmc.2020-0043
- Vacca L, Rosso V, Gastaldi L. Risk assessment in different judo techniques for children and adolescent athletes. *Proc Inst Mech Eng H.* (2020) 234(7):686–96. doi: 10.1177/0954411920915589
- Frassinelli S, Nicolai A, Zich RE, Rosso V, Gastaldi L. Quantification of motor abilities during the execution of judo techniques. *Acta Bioeng Biomech.* (2019) 21(3):3–12. doi: 10.5277/ABB-01346-2019-01
- Cetinić M, Dukarić V, Segedi I, Rupčić T, Sertić H. Defining the influence of fatigue protocol on kinematic parameters of ippon seoi nage. *Appl. Sci.* (2022) 12:9269. doi: 10.3390/app12189269
- Franchini E, Del Vecchio FB, Matsushigue KA, Artioli GG. Physiological profiles of elite judo athletes. *Sports Med.* (2011) 41(2):147–66. doi: 10.2165/11538580-000000000-00000
- Sterkowicz-Przybycień K, Miarka B, Fukuda DH. Sex and weight category differences in time-motion analysis of elite judo athletes: implications for assessment and training. *J Strength Cond Res.* (2017) 31(3):817–25. doi: 10.1519/JSC.0000000000001597
- Agostinho MF, Franchini E. Observational analysis of the variability of actions in judo: the key for success? *RAMA.* (2021) 15(2):69–77. doi: 10.18002/rama.v15i2.6341
- Cohen J. *Statistical Power for the Behavioral Sciences.* Hillsdale (NJ): Lawrence Erlbaum Associates (1988).
- ActiGraph. *GT3X+ And wGT3X+ Device Manual.* Pensacola, FL (2013).
- Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc.* (1982) 14:377–81.
- Franchini E, Takito MY, Nakamura FY, Matsushigue KA, Peduti MA. Effects of recovery type after a judo combat on blood lactate remove and on performance in an intermittent anaerobic task. *J Sports Med Phys Fitness.* (2003) 43(4):424–31.
- Santos-Lozano A, Marin PJ, Torres-Luque G, Ruiz JR, Lucia A, Garatachea N. Technical variability of the GT3X accelerometer. *Med Eng Phys.* (2012) 34(6):787–90. doi: 10.1016/j.medengphy.2012.02.005
- Freedson PS, Melanson E, Sirard J. Calibration of the computer science and applications, inc. Accelerometer. *Med Sci Sports Exerc.* (1998) 30:777–81. doi: 10.1097/00005768-199805000-00021
- Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. *J Am Coll Cardiol.* (2011) 37:153–56. doi: 10.1016/s0735-1097(00)01054-8
- Huber PJ. *Robust Statistics.* New York: Wiley (1981).
- Rosenthal R. *Meta-analytic procedures for social research.* Newbury Park, CA: Sage (1991).
- Harrison RL. Introduction to monte carlo simulation. *AIP Conf Proc.* (2010) 5(1204):17–21. doi: 10.1063/1.3295638
- Freedson PS, Pober D, Janz KF. Calibration of accelerometer output for children. *Med Sci Sports Exerc.* (2005) 37(11):523–30. doi: 10.1249/01.mss.0000185658.28284.ba
- Miarka B, Pérez DIV, Aedo-Muñoz E, da Costa LOF, Brito CJ. Technical-tactical behaviors analysis of male and female judo Cadets' combats. *Front. Psychol.* (2020) 11:1389. doi: 10.3389/fpsyg.2020.01389
- Santos L, Fernández-Río J, Iglesias-Soler E, Blanco-Traba M, Jakobsen MD, González-Díez V, et al. Postural control and physiological responses to a simulated match in U-20 judo competitors. *Sports Biomech.* (2020) 19(3):281–94. doi: 10.1080/14763141.2018.1461237
- Sbriccoli P, Bazzucchi I, Di Mario A, Marzattinocci GF, Felici F. Assessment of maximal cardiorespiratory performance and muscle power in the Italian Olympic judoka. *J Strength Cond Res.* (2007) 21:738–44. doi: 10.1519/R-20245.1
- Bonitch-Domínguez J, Bonitch-Góngora J, Padial P, Feriche B. Changes in peak leg power induced by successive judo bouts and their relationship to lactate production. *J Sports Sci.* (2010) 28:1527–34. doi: 10.1080/02640414.2010.512641
- Bonitch-Góngora JG, Bonitch-Domínguez JG, Padial P, Feriche B. The effect of lactate concentration on the handgrip strength during judo bouts. *J Strength Cond Res.* (2012) 26(7):1863–87. doi: 10.1519/JSC.0b013e318238ebac
- Chtourou H, Aloui A, Hammouda O, Chaouachi A, Karim Chamari K, Souissi N. The effect of time-of-day and judo match on short-term maximal performances in judokas. *Biol. Rhythm Res.* (2013) 44(5):797–806. doi: 10.1519/JSC.0b013e31827f4792
- Stavrinou PS, Argyrou M, Hadjicharalambous M. Physiological and metabolic responses during a simulated judo competition among cadet athletes. *Int J Perform Anal Sport.* (2016) 16(3):848–59. doi: 10.1080/24748668.2016.11868933

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.



## OPEN ACCESS

## EDITED BY

Alex Ojeda-Aravena,  
Pontificia Universidad Católica de Valparaíso,  
Chile

## REVIEWED BY

Nicholas Wise,  
Arizona State University, United States  
Kailei Foltmer,  
Arizona State University Tempe, United States,  
in collaboration with reviewer [NW]

## \*CORRESPONDENCE

Guodong Zhang  
✉ guodong-zhang@foxmail.com

RECEIVED 04 February 2024

ACCEPTED 15 March 2024

PUBLISHED 28 March 2024

## CITATION

Li Y, Li H, Li D, Zhang X, Wang Z, Green T and  
Zhang G (2024) What is hindering Chinese  
women from participating in combat sports?  
Front. Sports Act. Living 6:1381895.  
doi: 10.3389/fspor.2024.1381895

## COPYRIGHT

© 2024 Li, Li, Li, Zhang, Wang, Green and  
Zhang. This is an open-access article  
distributed under the terms of the [Creative  
Commons Attribution License \(CC BY\)](#). The  
use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# What is hindering Chinese women from participating in combat sports?

Yike Li<sup>1</sup>, Hansen Li<sup>1</sup>, Dongchen Li<sup>1</sup>, Xing Zhang<sup>2</sup>, Zhenhuan Wang<sup>3</sup>,  
Thomas Green<sup>4</sup> and Guodong Zhang<sup>1,5\*</sup>

<sup>1</sup>Institute of Sport Science, College of Physical Education, Southwest University, Chongqing, China,

<sup>2</sup>Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada,

Granada, Spain, <sup>3</sup>Institute for Health and Sport (iHeS), Victoria University, Melbourne, VIC, Australia,

<sup>4</sup>Department of Anthropology, Texas A&M University, College Station, TX, United States, <sup>5</sup>International  
College, Krirk University, Bangkok, Thailand

With the awakening of female consciousness, women's participation in sports has gradually gained autonomy and agency. However, Chinese women still face numerous restrictions in combat sports, hindering the development of this industry. Based on years of practice and research experience in the field, we summarize some general and specific issues, such as stigmatization and the constraints of traditional Chinese thinking. These issues need attention and consideration in the pursuit of gender equality in sports in the future.

## KEYWORDS

feminism, women's combat sports, combat sports, sexual harassment, sports media

## 1 Introduction

During China's feudal patriarchal era in China, the most common gender division was the principle of "men work outside (home) and women work inside". This model was achieved through the suppression and denial of women by men (1). During this period, there was a prevailing belief in the superiority of men over women, reducing women to subordinate roles.

After the Opium War (1840–1842) in the Qing dynasty (1616–1912), women began to step out of their homes to participate in social labor, laying the class foundation for the rise of the Chinese women's liberation movement (2). With the emergence of the early women's rights movement in the early days of the People's Republic of China and the ideological liberation brought about by the May Fourth Movement (a significant event in the Chinese New Democratic Revolution), the status of Chinese women was improved. They gained certain rights in areas such as the economy, education, marriage, political participation, and law (3).

Feminism is a political and social movement aimed at advocating for women's equal rights, opportunities, and status. Under the waves of feminist thought and the women's liberation movement, modern women have broken free from past constraints and can, in most cases, freely participate in sports. The international feminist movement, especially after the third wave, has had a significant impact on the inclusion of women's sports events in the Olympic Games (4). Female athletes have started to appear in traditionally male-dominated sports such as judo (5), wrestling (6), and even boxing (7). Since then, female martial artists have gradually entered the public view.

At the end of the 20th century and the beginning of the 21st century, under the influence of Western sports, combat sports such as boxing, Sanda, Taekwondo, kickboxing, and mixed martial arts (MMA) began to rise in China, providing



opportunities for female participation (8, 9). However, in the initial stages, female participation was largely limited, and most combat sports were still predominantly male-dominated (10–12). With social progress and the improvement of women's rights, the interest and opportunities for Chinese women to participate in combat sports gradually increased. Some influential female combat athletes, such as Weili Zhang (UFC athlete), began to emerge, inspiring more women to engage in combat sports.

Despite these advancements, most women still face limitations imposed by traditional systems, culture, and other factors. For example, combat sports are often described as “hyper-masculine (13–15)”, leading to stereotypes and biases against women in public perception and media portrayal. This indirectly results in a severe gender imbalance in the participation of combat competitions (16).

Empirically, participation in combat sports enables women to overcome physiological and psychological limitations, enhance self-confidence (17), and face difficulties with greater confidence in other domains. Furthermore, combat sports empower women and grant them autonomy (18), breaking traditional gender roles and demonstrating their ability to achieve remarkable results in the arena. This, in turn, may contribute to changing societal stereotypes and gender perceptions. Given these benefits, we believe that breaking the existing gender barriers and enabling more women to freely participate in combat sports would be of extraordinary significance.

However, it's essential to recognize that China has a unique historical and cultural background, and women may face many unusual challenges when participating in combat sports. Understanding these challenges can provide directions for our efforts toward gender equality in the future. Given the current lack of dedicated articles discussing this topic, we present several perspectives based on conducting combat training and research in China.

## 2 Results and discussion

### 2.1 Influence of traditional Chinese thought

The basic characteristics of traditional Chinese culture include a focus on ethics, advocating moral superiority, emphasizing harmony and unity, pursuing stability, and valuing rationality and humanistic education (19). The Confucian concept of “li” [礼] (20) (norms and rituals that individuals should follow in social life) has, to some extent, placed invisible constraints on competition, greatly hindering the development of competitive sports activities (21). For example, during the Western Zhou period (1046–771 BCE), the development of archery rituals excessively adhered to “li”, gradually losing its competitive nature. The Analects of Confucius mentions, “A gentleman has nothing to contend with others; if there is, it must be in archery game. In a game, they bow to each other in courtesy before starting. After the game, they drink together gentlemanly. This is a competition befitting a gentleman” [君子无所争, 必也射乎! 揖让而升, 下而饮。其争也君子] (22). This emphasizes

humility and courtesy, discouraging competition. The Classic of Filial Piety states, “The body, hair, and skin—received from one's parents, one may not injure. This is the beginning of filial piety” [身体发肤, 受之父母, 不敢毁伤, 孝之始也] (23). This suggests that everything on the body is a gift from parents and must not be harmed, discouraging risky activities and making people unwilling to engage in dangerous sports (24). The Doctrine of the Mean (a philosophy of moderation) downplays people's competitive awareness. These viewpoints are obviously at odds with the survival principles of competitive sports and have long influenced the Chinese understanding of sports. This is the reason why many Chinese view combat sports as violent and brutal movements activities (25).

Moreover, the traditional Chinese culture characterized by Confucianism has imposed normative requirements on women, reinforcing the patriarchal gender roles of male dominance and female submissiveness. Concepts such as “three obediences (obey father before marriage, husband after marriage, and son after husband's death)” and “four virtues (morality, speech, appearance, and household management)” emphasize male superiority and female inferiority, reinforcing feudal ideas. Confucianism's paternalistic system and ethical views severely restricted the development of women's sports, stipulating that women shall not participate in sports activities, depriving them of the right to sports and stifling their athletic desires. For example, the traditional saying in Chinese martial arts, “Kungfu must be conveyed to male but not to female” [传男不传女], fundamentally cut off opportunities for women to participate in martial arts sports (26).

### 2.2 Constraints of societal gender role expectations

Gender in the context of traditional Chinese culture refers to the differentiation of sex, implying a strict boundary between human males and females (27). Social gender, first proposed by feminist Oakley, is a concept relative to biological sex (28), which refers to societal expectations and norms regarding the characteristics, roles, activities, and responsibilities of men and women. Unlike the innate physiological and natural gender, social gender has been shaped by thousands of years of patriarchal society, a result of male-dominated culture (29). Social gender is a mutable, uncertain cultural construct (30), where the thoughts, behaviors, and interactions of men and women are influenced by societal norms, forming an already-established ideology of inequality. This intentional construct confines women, marking their bodies with distinctive symbols, and instructing them to exhibit personality traits deemed appropriate for females. Such constraints prevent them from resisting within the male-dominated environment (31). Consequently, individuals naturally align their cultural behaviors with gender expectations, with men and women respectively playing roles based on societal role expectations. Scholars have found that sports reflect and construct a deeper sense of male superiority and female inferiority than any other social

institution (32). The societal construction of women's roles implies that women must participate in specific sports, primarily those emphasizing aesthetic qualities, while most physically confrontational, intense, and high-intensity sports are traditionally considered male domains (33, 34). Women unwittingly internalize these frameworks as psychological biases, leading to compromises and value identification with gender roles. This role positioning, combined with gender differences, influences women's behavioral choices and expressions of interest in sports participation (35). Due to the intense confrontations involved, combat sports have naturally become sports suitable for men. Women participating in sports traditionally deemed suitable for men challenge traditional gender roles and societal expectations (36).

## 2.3 The plague of stigmatization labels

In most cultures, the image of combat clashes with the societal construction of the ideal woman (37), leading to severe stereotypical impressions of female combat sports athletes. For the convenience of training, many female combat athletes keep short hair, becoming one of the most noticeable outward differences from their peers. Additionally, the prolonged training makes them muscular, easily earning them the label of "tomboy" (38, 39). When their achievements surpass those of males, it undoubtedly challenges and undermines the hegemonic status of male sports. Consequently, males often objectify female sports participants in a rejecting manner, then use discriminatory language to cast shadows on women's psychology to solidify their dominance.

Participating in this sport, where direct physical contact is central, female boxers are not only required to enhance physical fitness, skills, and proficiency in using violence but also must display their feminine image outside the boxing ring (40). Otherwise, because of participating in a "masculine" sport (41), they may be labeled as "homosexual" (42), subjected to discrimination and exclusion, and subjected to unwarranted speculation about their sexual orientation. Therefore, to balance the male-dominated world of sports and societal expectations of feminine qualities (43, 44), they adopt apology behavior (45), aligning their appearance and behavior with feminine expectations. For instance, by wearing pink or floral-patterned gloves, competing in skirts, and keeping long hair, they express their feminine characteristics to reduce the risk of being labeled (46).

## 2.4 The worries of "inappropriate contact"

Combat sports involve one-on-one training. In environments typically dominated by males, introducing direct physical contact sports for females may pose challenges (47). To quickly improve their technical skills, athletes need to spar with others having different styles and skill levels. Since female athletes are often scarce in training centers, they may find themselves engaging in

sparring sessions with male athletes. Various types of touches are involved in these sparring sessions, some lasting for extended periods. The contact points range from hands, forearms, waist, thighs, to the entire body. Confucian norms such as "men and women should not touch each other" 「男女授受不亲」 (emphasizes that men and women should not be overly close in cohabitation) (48) can lead to widespread gender anxiety, particularly concerning physical contact, when male and female athletes participate in combat sports training. Athletes are concerned about "inappropriate contact", such as touching someone's genitals, which can hinder some practitioners from focusing on the technical application of combat training (49), thus impeding the effectiveness of their training to some extent.

## 2.5 The excessive "concession" of male sparring partners during training

Combat sports fundamentally rely on live sparring for skill development, where technical proficiency is honed through continuous combat. However, in combat training, male athletes exhibit a tendency to "concession" when facing female athletes (49, 50). Some male combat athletes hold the viewpoint that female teammates lack the endurance to handle training, striking, or grappling at the same intensity as males (51, 52). While male athletes need to display a certain level of self-restraint in most combat training scenarios, such restraint can usually go excessive and become "concession". On one hand, this excessive "concession" makes it difficult for female athletes to gain rich combat experience, restricting their development. On the other hand, it may make female athletes struggle to find a sense of belonging in the training collective and lead to doubts about their identity as athletes. These negative feelings can further weaken their training motivation and participation. Moreover, if male athletes avoid sparring with females solely based on gender, it may deepen female athletes' awareness of gender discrimination. They might perceive it as an insurmountable barrier, affecting their view of the sport and society, thus hindering female athletes from gaining equal opportunities and treatment.

## 2.6 The burden of losing to male sparring partners

Contrary to the excessive "concession", another scenario arises in live sparring. When male athletes disregard any gender differences and engage female athletes as ordinary opponents, male athletes consistently gain the upper hand. This sporting experience may potentially reinforce essentialist beliefs about male physical superiority, emphasizing once again the biological differences that may exist between genders (53). Such experiences are likely to dent the confidence of female athletes, leading them to question their own worth. Ultimately, they may become increasingly apprehensive in facing male opponents, resulting in



subpar athletic performance and forming a vicious cycle of “fear—poor athletic performance—fear”. This situation is frequently brought up by female athletes in our years of combat training. Once this psychological shadow takes shape, it becomes a bottleneck in training, gradually causing athletes to lose interest in the sport. Such mental health issues for athletes should not be underestimated, as they may impact physical function and athletic performance, and in severe cases, lead athletes to announce retirement (54).

## 2.7 Sexual harassment

The definition of sexual harassment is complex, and commonly understood as gender-themed verbal, non-verbal, or physical behaviors, encompassing any unwanted sexual attention perceived as offensive, intimidating, or humiliating. This form of harassment can be intentional or unintentional, legal or illegal (55). In sports, often considered a male-dominated culture, various forms of discrimination against female athletes are prevalent (56, 57). Research indicates that over 30% of female athletes have experienced sexual harassment in sports (58), with higher proportions in masculinized sports (59). For instance, up to 41% of athletes report experiencing sexual harassment in combat sports scenarios (47). Over the past few decades, numerous news and criminal cases have highlighted the systemic issue of sexual harassment in combat sports (60). Unlike most sports, training with members of the opposite sex is common in combat sports due to the predominance of males. This might lead coaches or fellow athletes to exploit their positions for unnecessary physical contact (such as pinching, hugging, touching) or unwarranted comments on athletes' bodies, attire, and private lives.

Besides training partners, perpetrators of sexual harassment and abuse in sports are often individuals in positions of power (55). A survey once exposed a shocking fact that all interviewees had experienced sexual harassment from male authority figures in the sports industry (61). However, the victims were too afraid to report or fight back due to fear of retaliation or unfair treatment on the training field. The unique ranking system in combat sports, with its strict belt levels (e.g., white belt to black belt), exacerbates the severity of the sexual harassment issue. Athletes show respect and admiration for coaches and higher-ranked teammates. However, this respect can be distorted in some cases, becoming a catalyst for sexual harassment. Many victims have expressed that their respect for coaches or higher-ranked athletes became a factor in their victimization (60).

## 2.8 Inappropriate media reports

Media professionals provide various services to the public (62). However, sports media coverage suffers from severe gender imbalances. Studies show a significant lack of opportunities for reporting on female athletes on platforms like Twitter and

similar media (63). In daily reporting, the representation of female athletes in print media is only around 10%, and in broadcast media, it remains below 5% (64). In the United States, despite 40% of sports participation being by women, sports media typically allocates only 5%–8% of coverage to female athletes (65), and similar situations have been reported in other countries as well (66). Furthermore, Gender stereotypes still dominate news content, with sports media tweets more often focusing on the failures of female athletes and belittling their achievements (67). Research revealed that one-third of the tweets implied negative images highlighting the failures of female athletes (68). In such cases, female athletes are often underestimated and underappreciated, with more attention paid to their appearance, clothing, family, and personal relationships than their performance (69).

Media serves the market, providing audiences with what they need. Despite the considerable achievements of female sports, media descriptions of these athletes have long been influenced by objectification and invisibility. Compared to male athletes, female athletes are considered inferior, and media attention to the physical appearance of female athletes far exceeds their focus on their athletic skills and abilities (70, 71). Media sensationalizes female bodies, looks, and related matters to cater to the specific preferences of male audiences seeking “eye-catching stimuli”, attracting public attention. The emphasis on feminine traits such as breasts, buttocks, lips, and nails in sports reporting constructs a “gender hierarchy” in sports (72), marginalizing, trivializing, and devaluing women's athletic achievements. Such an online environment limits gender equality and women's progress. Combat sports provide a typical example. Due to the focus on the male-dominated consumer market, event organizers may host events like “Battle of Beauties”, featuring attractive female athletes, extensively promoting the matches before the event to gain attention. Such practices contradict the original principles of combat sports and place female athletes in a dilemma between pursuing their abilities or appearance.

## 3 Conclusion and future directions

In general, we have presented some perspectives concerning the challenges that Chinese women are facing in combat sports. Here we also make some points for future consideration when trying to cope with these challenges. First, we believe that the Chinese government's policy can play a pivotal role, as they have regulated the sports industries in China for decades. For example, developing some physical education based on combat sports in schools can give female students more chances to understand such sports and foster related interests. Second, we could resort to the “leader effect”. Since some famous athletes such as Weili Zhang have earned great influence in UFC and gradually attracted a number of fans in China, more events in China that they can attend may draw the attention of more women to this sport. Thirdly, we can concentrate on developing some extensions or variants that are relatively easy

to play and watch, somewhat similar to flag football (a variant of American football). Such variants can be more friendly for the general female population, thus forming a better foundation for more professional combat sports.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Author contributions

YL: Writing – original draft, Conceptualization, Methodology, Writing – review & editing. HL: Writing – review & editing, Methodology. DL: Supervision, Writing – review & editing. XZ: Supervision, Writing – review & editing. ZW: Supervision, Writing – review & editing. TG: Supervision, Writing – review & editing. GZ: Supervision, Writing – review & editing.

## References

- Li B. The absence and presence of gender consciousness: an insight into the debate on “women returning home” during the reform era. *J Shanxi Normal Univ (Soc Sci Edit)*. (2006) 6:112–5.
- Zhao MY. Traditional and modern: professional role conflict of modern Chinese women. (Master's thesis). China: Guangxi Normal University, Guangxi Zhuang Autonomous Region (2004).
- He LP. Early 1940s polemic about “women returning home” issue. *J Sichuan Normal Univ (Soc Sci Edit)*. (2006) 3:138–44.
- Xie MQ. Discussing the impact of the Olympics on women's right. *Acad J Humanit Soc Sci*. (2021) 4(12):58. doi: 10.25236/AJHSS.2021.041211
- Miarka B, Marques JB, Franchini E. Reinterpreting the history of Women's Judo in Japan. *Int J Hist Sport*. (2011) 28(7):1016–29. doi: 10.1080/09523367.2011.563633
- Stuart M, Whaley D. Resistance and persistence: an expectancy-value approach to understanding Women's participation in a male-defined sport. *Women Sport Phys Act J*. (2005) 14:24. doi: 10.1123/wspaj.14.2.24
- Jennings LA. *She's a Knockout!: A History of Women in Fighting Sports*. Lanham: Rowman & Littlefield (2014).
- Spencer DC. Habit(us), body techniques and body callusing: an ethnography of mixed martial arts. *Body Soc*. (2009) 15(4):119–43. doi: 10.1177/1357034X09347224
- Tjønndal A. ‘I don't think they realise how good we are’: innovation, inclusion and exclusion in women's Olympic boxing. *Int Rev Sociol Sport*. (2019) 54(2):131–50. doi: 10.1177/1012690217715642
- Lafferty Y, McKay J. Suffragettes in satin shorts”? gender and competitive boxing. *Qual Sociol*. (2004) 27(3):249–76. doi: 10.1023/B:QUAS.0000037618.57141.53
- Satterlund TD. Real, but not too real: a hierarchy of reality for recreational middle-class boxers. *Sociol Perspect*. (2012) 55(3):529–51. doi: 10.1525/sop.2012.55.3.529
- Tjønndal A. The inclusion of Women's boxing in the Olympic games: a qualitative content analysis of gender and power in boxing. *Qual Soc Rev*. (2016) 12(3):3. doi: 10.18778/1733-8077.12.3.04
- Alsarve D, Tjønndal A. “The nordic female fighter”: exploring women's participation in mixed martial arts in Norway and Sweden. *Int Rev Sociol Sport*. (2020) 55(4):471–89. doi: 10.1177/1012690218822307
- Kavoura A, Kokkonen M, Ani CS, Ryba TV. “Some women are born fighters”: discursive constructions of a Fighter's identity by female Finnish Judo athletes. *Sex Roles*. (2018) 79(3):239–52. doi: 10.1007/s11199-017-0869-1
- Matthews CR. The tyranny of the male preserve. *Gend Soc*. (2016) 30(2):312–33. doi: 10.1177/0891243215620557
- Channon A. Towards the “Undoing” of gender in mixed-sex martial arts and combat sports. *Societies*. (2014) 4(4):4. doi: 10.3390/soc4040587
- Velija P, Mierzewski M, Fortune L. ‘It made me feel powerful’: Women's gendered embodiment and physical empowerment in the martial arts. *Leis Stud*. (2013) 32(5):524–41. doi: 10.1080/02614367.2012.696128
- Mierzewski M, Velija P, Malcolm D. Women's experiences in the mixed martial arts: a quest for excitement? *Sociol Sport J*. (2014) 31(1):66–84. doi: 10.1123/ssj.2013-0125
- Chen ZX. The confucian cultural consciousness in competitive sports in China. (Master's thesis). Fuzhou, Fujian, China: Fujian Normal University (2013).
- Dai S. (Ed.). Pingsheng H, Meng Z, Trans. *Liji*. China: Zhonghua Book Company (2022). Available online at: <https://book.douban.com/subject/27601609/> (Accessed January 23, 2024).
- Li N, Liu J, Lin T, Chu FG. Confucian culture influence on Chinese sports culture. *Contemp Sports Technol*. (2013) 3(16):155–6. doi: 10.16655/j.cnki.2095-2813.2013.16.093
- Liu SL. (Trans.). *The Analects*. China: Zhonghua Book Company (2006). Available online at: <https://book.douban.com/subject/1964774/>
- Hu PS. (Trans.). *Notes and Translation of the Classic of Filial Piety*. China: Zhonghua Book Company (1996). Available online at: <https://book.douban.com/subject/1042419/>
- Sun QB. The negative influence of confucianism on physical education in China. *J Phys Educ*. (2004) 6:139–41. doi: 10.16237/j.cnki.cn44-1404/g8.2004.06.044
- Gauthier J. Ethical and social issues in combat sports: should combat sports be banned? In: Kordi R, Maffulli N, Wroble RR, Wallace WA, editors. *Combat Sports Medicine*. London: Springer (2009). p. 73–88. doi: 10.1007/978-1-84800-354-5\_5
- Fang GQ. The historical and cultural authenticity of Wushu legend narration. *J Beijing Sport Univ*. (2023) 46(2):62–72. doi: 10.19582/j.cnki.11-3785/g8.2023.02.007
- Yin Y. Identity and difference: gender attribute recognition of body drill. *J Sports Sci*. (2016) 37(2):50–54+79. doi: 10.13598/j.issn1004-4590.2016.02.009
- Deaux K. Sex and gender. *Annu Rev Psychol*. (1985) 36(1):49–81. doi: 10.1146/annurev.ps.36.020185.000405
- Wood HJ. Gender inequality: the problem of harmful, patriarchal, traditional and cultural gender practices in the church. *HTS Teol Stud Theol Stud*. (2019) 75(1):1. doi: 10.4102/hts.v75i1.5177
- Wood W, Eagly AH. A cross-cultural analysis of the behavior of women and men: implications for the origins of sex differences. *Psychol Bull*. (2002) 128(5):699–727. doi: 10.1037/0033-2909.128.5.699
- Chen JS, Min J. Body, power and sports participation under the perspective of feminism. *China Sport Sci*. (2014) 34(7):12–14+48. doi: 10.16469/j.css.2014.07.002

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

32. Kane MJ. Media coverage of the post title IX female athlete: a feminist analysis of sport, gender, and power. *Duke J Gender L Policy*. (1996) 3:95.
33. Lindner K. Women's boxing at the 2012 Olympics: gender trouble? *Fem Media Stud*. (2012) 12(3):464–7. doi: 10.1080/14680777.2012.698092
34. Riemer BA, Visio ME. Gender typing of sports: an investigation of Metheny's classification. *Res Q Exerc Sport*. (2003) 74(2):193–204. doi: 10.1080/02701367.2003.10609081
35. Chalabaev A, Sarrazin P, Fontayne P, Boiché J, Clément-Guillotin C. The influence of sex stereotypes and gender roles on participation and performance in sport and exercise: review and future directions. *Psychol Sport Exerc*. (2013) 14(2):136–44. doi: 10.1016/j.psychsport.2012.10.005
36. Ahmed Laar R, Perveen S, Ashraf MA. Young women as change agents in sports and physical activities in the Punjab (Southern) province of Pakistan. *Front Psychol*. (2022) 13:857189. doi: 10.3389/fpsyg.2022.857189
37. Kavoura A, Ryba TV, Chroni S. Negotiating female judoka identities in Greece: a Foucauldian discourse analysis. *Psychol Sport Exerc*. (2015) 17:88–98. doi: 10.1016/j.psychsport.2014.09.011
38. Kostas M. 'Real' boys, sissies and tomboys: exploring the material-discursive intra-actions of football, bodies, and heteronormative discourses. *Br J Sociol Educ*. (2022) 43(1):63–83. doi: 10.1080/01425692.2021.1999790
39. Vu MB, Murrie D, Gonzalez V, Jobe JB. Listening to girls and boys talk about Girls' physical activity behaviors. *Health Educ Behav*. (2006) 33(1):81–96. doi: 10.1177/1090198105282443
40. Schneider P. Sparring with patriarchy: the rise of female boxers in the Global South. *J Gen Stud*. (2021) 30(8):887–900. doi: 10.1080/09589236.2020.1826294
41. Matthews CR. Biology ideology and pastiche hegemony. *Men Masc*. (2014) 17(2):99–119. doi: 10.1177/1097184X14526699
42. Craig T, LaCroix J. Tomboy as protective identity. *J Lesbian Stud*. (2011) 15(4):450–65. doi: 10.1080/10894160.2011.532030
43. Follo G. A literature review of women and the martial arts: where are we right now? *Sociol Compass*. (2012) 6(9):707–17. doi: 10.1111/j.1751-9020.2012.00487.x
44. Russell KM. On versus off the pitch: the transiency of body satisfaction among female rugby players, cricketers, and netballers. *Sex Roles*. (2004) 51(9):561–74. doi: 10.1007/s11199-004-5466-4
45. Davis-Delano LR, Pollock A, Ellsworth Vose J. Apologetic behavior among female athletes: a new questionnaire and initial results. *Int Rev Sociol Sport*. (2009) 44(2–3):131–50. doi: 10.1177/1012690209335524
46. Carlsson H. Researching boxing bodies in Scotland: using apprenticeship to study the embodied construction of gender in hyper masculine space. *Gen Place Cult*. (2017) 24(7):939–53. doi: 10.1080/0966369X.2017.1343282
47. Mathisen TF, Kumar RS, Svantorp-Tveiten KME, Sundgot-Borgen J. Empowered, yet vulnerable: motives for sport participation, health correlates, and experience of sexual harassment in female combat-sport athletes. *Sports*. (2022) 10(5):68. doi: 10.3390/sports10050068
48. Wang J. The eternal value of Confucian ritual and moral education: taking “men and women should not touch each other while giving or receiving” as an example. *Confucius Stud*. (2015) 3:28–35.
49. Channon A, Jennings G. The rules of engagement: negotiating painful and «intimate» touch in mixed-sex martial arts. *Sociol Sport J*. (2013) 30(4):487–503. doi: 10.1123/ssj.30.4.487
50. Nash M. Gender on the ropes: an autoethnographic account of boxing in Tasmania, Australia. *Int Rev Sociol Sport*. (2017) 52(6):734–50. doi: 10.1177/1012690215615198
51. Guérandel C, Mennesson C. Gender construction in Judo interactions. *Int Rev Sociol Sport*. (2007) 42(2):167–86. doi: 10.1177/1012690207084750
52. McNaughton M. (2015). *Insurrectionary womanliness: gender and the (boxing) ring. The Qualitative Report*. doi: 10.46743/2160-3715/2012.1781
53. Channon AG. Enter the discourse: exploring the discursive roots of inclusivity in mixed-sex martial arts. *Sport Soc*. (2013) 16(10):1293–308. doi: 10.1080/17430437.2013.790896
54. Haugen E. Athlete mental health & psychological impact of sport injury. *Oper Tech Sports Med*. (2022) 30(1):150898. doi: 10.1016/j.otsm.2022.150898
55. Marks S, Mountjoy M, Marcus M. Sexual harassment and abuse in sport: the role of the team doctor. *Br J Sports Med*. (2012) 46(13):1. doi: 10.1136/bjsports-2011-090345
56. Fasting K, Brackenridge C, Knorre N. Performance level and sexual harassment prevalence among female athletes in the Czech Republic. *Women Sport Phys Act J*. (2010) 19(1):26–32. doi: 10.1123/wspaj.19.1.26
57. Volkwein KAE, Schnell FI, Sherwood D, Livezey A. Sexual harassment in sport: perceptions and experiences of American female student-athletes. *Int Rev Sociol Sport*. (1997) 32(3):283–95. doi: 10.1177/1012690297032003005
58. Fasting K, Chroni S, Hervik SE, Knorre N. Sexual harassment in sport toward females in three European countries. *Int Rev Sociol Sport*. (2011) 46(1):76–89. doi: 10.1177/1012690210376295
59. Fasting K, Brackenridge C, Sundgot-Borgen J. Prevalence of sexual harassment among Norwegian female elite athletes in relation to sport type. *Int Rev Sociol Sport*. (2004) 39(4):373–86. doi: 10.1177/1012690204049804
60. Milford M. Full contact: sexual assault, combat sports, and the myth of self-defense. *Commun Sport*. (2021) 9(3):418–37. doi: 10.1177/2167479519868798
61. Fasting K, Brackenridge C, Walseth K. Women Athletes' personal responses to sexual harassment in sport. *J Appl Sport Psychol*. (2007) 19(4):419–33. doi: 10.1080/10413200701599165
62. Brett G. Reframing the 'Violence' of mixed martial arts: the 'Art' of the fight. *Poetics*. (2017) 62:15–28. doi: 10.1016/j.poetic.2017.03.002
63. Adá Lameiras A, & Rodríguez-Castro Y. The presence of female athletes and non-athletes on sports media Twitter. *Fem Media Stud*. (2021) 21(6):941–58. doi: 10.1080/14680777.2020.1732439
64. Bruce T. Reflections on communication and sport: on women and femininities. *Commun Sport*. (2013) 1(1–2):125–37. doi: 10.1177/2167479512472883
65. Hardin M, Greer JD. The influence of gender-role socialization, media use and sports participation on perceptions of gender-appropriate sports. *J Sport Behav*. (2009) 32(2):207–26. <https://www.proquest.com/docview/215875384/abstract/AB51AD88B8854C79PQ/1>
66. Jakubowska H, Channon A, Matthews CR. Gender, media, and mixed martial arts in Poland: the case of Joanna Jędrzejczyk. *J Sport Soc Issues*. (2016) 40(5):410–31. doi: 10.1177/0193723516655578
67. Musto M, Cooky C, Messner MA. “From fizzle to sizzle!” televised sports news and the production of gender-bland sexism. *Gen Soc*. (2017) 31(5):573–96. doi: 10.1177/0891243217726056
68. Adá-Lameiras A, Rodríguez-Castro Y. Analysis from a gender perspective of the Olympic games on Twitter. *Eur Sport Manag Q*. (2023) 23(3):683–99. doi: 10.1080/16184742.2021.1910965
69. Yip A. Deuce or advantage? Examining gender bias in online coverage of professional tennis. *Int Rev Sociol Sport*. (2018) 53(5):517–32. doi: 10.1177/1012690216671020
70. Knight JL, Giuliano TA. He's a laker; She's a “looker”: the consequences of gender-stereotypical portrayals of male and female athletes by the print media. *Sex Roles*. (2001) 45(3):217–29. doi: 10.1023/A:1013553811620
71. Trolan EJ. The impact of the media on gender inequality within sport. *Procedia Soc Behav Sci*. (2013) 91:215–27. doi: 10.1016/j.sbspro.2013.08.420
72. Toffoletti K. How is gender-based violence covered in the sporting news? An account of the Australian football league sex scandal. *Women's Stud Int Forum*. (2007) 30(5):427–38. doi: 10.1016/j.wsif.2007.07.004



## OPEN ACCESS

## EDITED BY

Alberto Ruiz-Ariza,  
University of Jaén, Spain

## REVIEWED BY

Awadhesh Kumar Shirotriya,  
Fiji National University, Fiji  
Marie Elizabeth Magdalena Young,  
University of the Western Cape, South Africa

## \*CORRESPONDENCE

Yuanlong Cheng  
✉ 576632052@qq.com

RECEIVED 03 March 2024

ACCEPTED 23 April 2024

PUBLISHED 15 May 2024

## CITATION

Cheng Y and Guo N (2024) An ethnography of construction and characteristics of curriculum for inheritance of intangible cultural heritage martial arts in universities.

Front. Sports Act. Living 6:1395128.  
doi: 10.3389/fspor.2024.1395128

## COPYRIGHT

© 2024 Cheng and Guo. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# An ethnography of construction and characteristics of curriculum for inheritance of intangible cultural heritage martial arts in universities

Yuanlong Cheng<sup>1,2\*</sup> and Nana Guo<sup>3</sup>

<sup>1</sup>Graduate School/Discipline Construction Division, Cheng Du Sport University, Chengdu, China,

<sup>2</sup>Department for Improvement of Teachers, China West Normal University, Nanchong, China,

<sup>3</sup>Department of Sports, Xishan Foreign Language Experimental School, Nanchong, China

**Background:** Inheriting excellent traditional Chinese culture is a prerequisite for ensuring the continuity of the cultural genes of the Chinese nation. However, with the historical mission of shaping the national character of the descendants of the Chinese nation, intangible cultural heritage martial arts face the problem of an unclear curriculum content construction mechanism in university inheritance and make it difficult for these martial arts to shoulder the responsibility of cultural inheritance in the era.

**Method:** Educational ethnography as a research method is conducive to the in-depth exploration of the mechanism of curriculum content construction in the inheritance of intangible cultural heritage martial arts in universities.

**Results:** Research suggests that the construction of curriculum content for the inheritance of intangible cultural heritage martial arts in universities relies on the form of cooperation between universities and inheritors, and form three models of curriculum content construction: off campus, on campus, and on-campus cooperation. The construction of curriculum content for off-campus inheritors belongs to the “attachment style” model, which is based on the actual needs of the inheritors and the selection of boxing types. The construction of curriculum content for inheritors on campus belongs to the “reshaping” model, which is the inheritor’s “simplification and reorganization” based on traditional routines and subjective and objective conditions of inheritance. The construction of course content in school local cooperation belongs to the “integrated” model, which is the reintegration of course content by universities based on their own development characteristics and the characteristics of various martial arts.

**Conclusion:** In the inheritance of intangible cultural heritage martial arts in universities, emphasis is placed on local knowledge, core skills, cultural traditions, and other characteristics, highlighting the excellence of its cultural inheritance. In the future, the focus of the inheritance of these martial arts in universities should be to cultivate innovative talents who are familiar with both traditional and modern martial arts.

## KEYWORDS

curriculum construction, intangible cultural heritage martial arts, martial arts education, traditional culture, local knowledge



# 1 Introduction

China's excellent traditional culture inherits the continuity of the cultural bloodline of the Chinese nation and bears the responsibility of shaping the national character of the descendants of China. As a typical representative of China's excellent traditional culture, intangible cultural heritage martial arts play an important role in maintaining the national bloodline and shaping the national character, especially in shaping the worldview, values, and outlook on life of contemporary college students, which determine the question of "what kind of person" the young generation of college students should be cultivated into. However, in the process of inheriting intangible cultural heritage martial arts in universities, "martial arts in physical education classes at all levels of ordinary schools tend to enhance students' physical fitness, cultivate national spirit, and are more inclined toward the 'utilization' of martial arts, unable to bear the heavy responsibility of inheriting intangible cultural heritage martial arts" (1), "despite repeated calls from scholars and continuous measures taken by the government and schools, the results have been minimal" (2). Ultimately, the key to the educational inheritance of intangible cultural heritage martial arts in schools lies in the construction of curriculum content, which determines the nature of student cultivation. In addition, the introduction of these martial arts into campuses has attracted the attention of many scholars, and many universities have also offered intangible cultural heritage martial arts courses (3). However, the curriculum construction mechanism in the inheritance of intangible cultural heritage martial arts in universities is still unclear, resulting in the cultural inheritance of these martial arts in universities being in vain. Based on this, the present study examines the inheritance of Sichuan intangible cultural heritage martial arts in universities as a local experience through using participatory observation and in-depth interviews. It studies the process of curriculum construction in the inheritance of intangible cultural heritage martial arts in universities. It then condenses the characteristics of curriculum construction in the inheritance of intangible cultural heritage martial arts in universities, and explores how traditional martial arts culture can be integrated into the modern educational system.

# 2 Literature review

The construction of curriculum plays an important role in school education in China, and a series of policies have been formulated to support curriculum construction. Since 1998, China has continuously adjusted and reformed its curriculum system, gradually establishing a three-level curriculum system consisting of national curriculum, local curriculum, and school-based curriculum. In 1999, the decision was made to deepen education reform and comprehensively promote quality education. In 2001, a new round of curriculum reform was implemented, and in 2010, the National Medium- and Long-Term Education Reform and Development Plan Outline

(2010–2020) was formulated. In 2012, the revised national curriculum standards for various disciplines were promulgated and implemented. Although there are over 100 concepts about curriculum, the curriculum began to shift from curriculum development to curriculum understanding after the 1980s. "The essence of curriculum lies in constructing culture" (4). Scholars have proposed a representative curriculum view, where curriculum refers to subject textbooks, teaching plans, teaching objectives, and learning experiences (5). There have also been studies exploring the issue of curriculum views from the relationship between structuralism and constructivism. It is believed that the common goal of both theories is to break through the surface disciplines of knowledge structure and move toward the deep structure of basic concepts in curriculum construction (6). Although these concepts are expressed differently, they all emphasize the issue of what to teach. Researchers have summarized the trends and characteristics of international curriculum reform, including focusing on student development and emphasizing the cultivation of skills needed to adapt to modern society; emphasizing the integration of the curriculum and the mutual integration between disciplines; integrating quality evaluation standards into the curriculum and emphasizing accountability; and the decentralization of educational management power and the centralization of curriculum evaluation power (7). Researchers have also studied the curriculum construction of mixed-age education for young children, believing that the construction of mixed-age courses must adhere to the principles of subjectivity and development, comprehensiveness and diversity, and interest and integration (8). At the same time, some scholars have proposed a constructive view on curriculum culture, which emphasizes that curriculum construction is not a linear program of indoctrination, rote memorization, mechanical stimulation, passive response and reinforcement, closed linear procedures, and rigid evaluation standards and methods, but rather a non-fixed and universal program or method (9). These studies further highlight the diversity in curriculum construction, making the concept of diverse curriculum construction a universal feature. However, with the acceleration of global integration, there have been some changes in the concept of curriculum construction, among which the concept of a multicultural education curriculum is prominent, especially in ethnic minority education. Some scholars advocate the use of "open curriculum" and "multicultural new curriculum models" in curriculum construction, rather than building a new curriculum, but integrating various distinctive cultures into the modern curriculum (10). Researchers have also discussed the theory and strategy of local cultural curriculum construction from an objective perspective. They believe that in local curriculum construction, the interaction between ethnic cultural inheritance and student cultural consciousness should be achieved, reflecting the nature of activity-based and comprehensive curriculum, focusing on theoretical orientations, such as knowledge and skills, processes and methods, emotional attitudes, and values. In terms of strategy, the combination of knowledge logic and life logic can be used to highlight comprehensive cultural events,

choose the form of student-centered dialogue, and lead teaching reform (11). Therefore, whether it is the construction of multicultural courses or local courses, it emphasizes the various possibilities of curriculum construction. Curriculum construction is a large concept that includes three steps: “identifying the theme, constructing a knowledge network around the theme; identifying, expressing lasting understanding and writing basic questions; and writing knowledge and skill goals” (12). Although researchers have gained in-depth understanding in curriculum construction, there are still some problems that have been addressed from different perspectives. For example, in response to issues such as detachment and lack of autonomy in curriculum construction, some researchers have conducted specialized research on these issues, further improving the system of embodied curriculum from three aspects: theoretical origins, core features, and embodied curriculum construction. In the construction of embodied curriculum, curriculum construction should be carried out from both horizontal and vertical dimensions (13). Some researchers also believe that contemporary curriculum construction should focus on cultivating students’ expectations of unrestricted thinking and critical thinking, considering the problems of cultural autonomy and autonomy in the old curriculum model (14). Especially in the context of the information age, some scholars have constructed information core literacy courses to solve the problem of not keeping up with the times due to the rapid transformation of the times (15). Some researchers also believe that curriculum construction has shifted from behaviorism to cognitive science in theory (16). From the perspective of cognitive science, these papers reflect on the deep-seated issues of curriculum construction.

In the field of martial arts, Chinese martial arts have always faced many new reforms since modern times, such as the reform from cultivating military war talents to cultivating modern martial arts sports talents, and from traditional ethnic sports to modern sports, so the education is an important aspect of its reform. As a result, many problems of martial arts education have been encountered, and related research is also relatively rich. Under the martial arts education model, martial arts in schools exhibit a certain degree of “educational vitality” (17), which helps “cultivate students’ physical literacy” (18), “shape their national spirit” (19, 20), and “promote aesthetic education” (21, 22). In the new historical context, the simultaneous development of “five educations” (23) has become a new trend in the development of martial arts education in schools. However, martial arts in schools also face various problems as they transition toward the field of education, such as “insufficient motivation after entering school education” (24) and “lack of humanistic spirit” (25); these difficulties in martial arts education in schools mainly manifest in “understanding and practice” (26). As a result, related research is also relatively rich. Some researchers believe that building a unique cultural system for martial arts education in schools, or implementing a curriculum centered on martial arts, is an effective way to achieve the prosperity and development of a martial arts education in schools (27). Some researchers have also introduced the Sport for

All theory and suggested that the school martial arts courses should be constructed according to the seasons (28).

However, this curriculum construction is still only at the theoretical level and has not yet entered specific curriculum practice, and the specific teaching results are not very clear. Some researchers have also studied the development of a school-based martial arts curriculum in primary and secondary schools, starting from the social background of “one school, one fist” (29). In order to gain a deeper understanding of the problems in curriculum construction, researchers conducted a survey of 252 ordinary primary and secondary schools in 30 provinces of China, believing that educational content should follow the combination of tradition and innovation, simplicity and systematicity, unity and diversity, fitness and combat, martial arts spirit and patriotism; the content level is divided into fun martial arts, skilled martial arts, and cultural martial arts; the content categories include nationally unified demonstration content, local boxing’s characteristics, and female content; the content composition includes bare hands, equipment, theoretical knowledge, among others (30). However, there is no specific plan for Chinese martial arts, so its practicality is insufficient.

At present, integrating ideological and political education into the curriculum has become a new approach for martial arts education in schools, aimed at fostering moral education and cultivating talents. In the context of ideological and political education in the curriculum, it is important to fully explore the ideological and political elements of martial arts and integrate martial arts education with ideological and political education. From the perspective of curriculum ideology, some researchers emphasized that the construction of physical education curriculum ideology is an urgent task for the construction of a strong sports country, the mission of school education, and the growth needs of college students (31). Some studies also suggest that an ideological and political curriculum is in line with school-based martial arts education in terms of educational philosophy, content, and subjects. In the context of this curriculum, the return of the “martial arts spirit” in martial arts education can be re realized (32). There are also researchers advocating for the reform of university martial arts courses, focusing on the essence of these courses, the cultural phenomenon of martial arts, and the cultural consciousness of martial arts courses to carry out ideological and political constructs (33). From the perspective of cultural inheritance, Liu Wenwu believes that the entry of traditional martial arts into the school system is the fundamental strategy for inheriting martial arts culture. Martial arts majors in sports colleges should shift their curriculum content from competitive martial arts to traditional martial arts. Martial arts teachers are encouraged to the people to learn local customs, while the school’s teaching authority should prioritize the retraining of martial arts teachers (34). Based on the needs of society and college students, Wu and Lv have developed a curriculum reform plan to response to the problems of single and outdated content, lack of martial arts characteristics in university martial arts courses, as well as the fragmentation, abandonment,

dismemberment, and piecing of martial arts curriculum reform. Their proposal has been empirically recognized by students, experts, and evaluations (35). In 1997, Lv and Peng pointed out the main problems faced by the reform of the martial arts curriculum in schools: mainly teachers and textbooks. These issues have been persistently challenging martial arts education. In curriculum construction, the overall goal of “valuing martial arts, promoting morality, and cultivating oneself” should be clearly defined, and the construction of the teaching staff should be strengthened along with the scientific nature of textbook selection (36). From these studies, it can be seen that the construction of a martial arts curriculum exhibits certain historical characteristics and maintains a high degree of consistency with the construction of a national curriculum. Therefore, in the context of cultural inheritance, how to play the role of the inheritance of intangible cultural heritage martial arts has become an urgent issue that needs attention at this time.

In summary, curriculum construction involves discussions and in-depth analyses from different theoretical perspectives and academic disciplines. However, these studies focus on theoretical and objective analyses, ignoring the thematic perspective of curriculum construction. In the field of martial arts, even though some research has examined curriculum reform through surveys, they have not delved deeply into the process of curriculum construction, resulting in curricula not fully meeting teaching needs. In the context of preserving intangible cultural heritage, in particular, the prominent regional characteristics of martial arts show significant differences in the curriculum construction of universities; how to carry out curriculum construction has not been effectively solved. Starting from the perspective of the subject, this study delves into the practice of inheriting intangible cultural heritage martial arts in universities. Through participatory observation and in-depth interviews, it explores the operational mechanism of curriculum construction in the inheritance of these martial arts in universities, summarizes the characteristics of curriculum construction, and further explores how traditional martial arts can be integrated into the modern educational system.

### 3 Materials and methods

This study mainly adopts field investigation methods to collect data through participatory observation and in-depth interviews, including “ethical rules, sampling, questioning, analysis, and memo” (37) to determine “the correct understanding of the research objects” (38). Five universities participated in the observation: Chengdu Sport University; China West Normal University, Neijiang Normal University, Leshan Vocational and Technical College, and Neusoft College in Chengdu. The in-depth interviews followed a semi-structured format in various settings, including offices, training interval, and the accommodation of inheritors of intangible cultural heritage martial arts. The first step of the study was to screen and select the participants. Then, the observation location was

determined. Finally, the data were organized and the paper was written completely.

#### 3.1 Selection of research object

The inheritance of intangible cultural heritage martial arts in universities is a cultural practice established through cooperation and negotiation between universities and intangible cultural heritage martial arts. As a result, not every university will carry out the inheritance of intangible cultural heritage martial arts. Furthermore, the inheritance of intangible cultural heritage martial arts in universities has characteristics of randomness, so it will be canceled at any time. Based on the instability of the inheritance of intangible cultural heritage martial arts in universities, this study undertook extensive work in the early stages to determine the programs including through official website and snowball methods. Finally, a list of universities and their intangible cultural heritage martial arts projects was completed.

Due to the blurred boundaries of concepts such as Sichuan martial arts, Emei martial arts, Bashu martial arts, there are also some difficulties in determining the object of this study. In light of this, the following measures were taken to clarify the research object and scope. First, the objects of intangible cultural heritage martial arts were clarified. This study only focuses on Sichuan intangible cultural heritage martial arts that have been approved by the state. These include martial arts approved at the national, provincial, municipal, or district level, all of which are within the scope of this study. In the school curriculum, the other martial arts that do not meet the intangible cultural heritage criteria were excluded. This was mainly to avoid non-Sichuan-approved martial arts being included in the study. The reason for this limitation is that universities are a gathering place for multiple martial arts, and the students are from various provinces in China, which is not conducive to the in-depth research of this study. Second, the scope of intangible cultural heritage martial arts was clarified. Because the enrollment of universities is all over the country, so the intangible cultural heritage martial arts projects are mixed from all over the country. Based on preliminary research, it was discovered that almost every university has a martial arts team and foreign intangible cultural heritage martial arts projects, such as Xingyi Boxing, Bagua Palm, Tai Chi Boxing, and so on. Intangible cultural heritage martial arts projects are extremely complex. Moreover, there are over 100 types of Chinese martial arts, and there are hundreds of universities in Sichuan Province. Therefore, the intangible cultural heritage martial arts projects were limited to Sichuan Province to streamline the scope of this study. Third, there are three basic conditions for the inheritance of intangible cultural heritage martial arts in universities: (1) there must be dedicated inheritors or teachers of intangible cultural heritage; (2) it must be an intangible cultural heritage martial arts project approved or recommended by Sichuan Province only; and (3) students must practice with them actively, and not just engage in temporary intangible cultural heritage activities such as cultural festivals and



cultural corridors. Only projects meeting the above three criteria are included in the scope of this study.

3.2 Selection of interviewees

This cooperation is established through thorough consultation between intangible cultural heritage martial arts entities and universities. Therefore, the inheritance of intangible cultural heritage martial arts in universities has not shown universal characteristics, and only some universities and intangible cultural heritage martial arts entities have collaborated. As a result, this study adopts a snowball approach to search for interviewees effectively. Two types of interviewees were selected as the focus: inheritors of intangible cultural heritage martial arts in Sichuan Province and teachers involved in tangible cultural heritage martial arts in universities. The reason for choosing Sichuan Province is that the enrollment system of universities determines the extremely wide variety of college students, which lead to diverse intangible cultural heritage martial arts. The inclusion of university inheritance teachers is those who have already taken on the mission of inheriting intangible cultural heritage martial arts. Specifically, when selecting interviewees, the interviewees should be those who have carried out intangible cultural heritage martial arts in universities. The teachers interviewed should be in-service university teachers who have implemented or are

currently implementing intangible cultural heritage martial arts teaching activities. Specific interview details are shown in Tables 1, 2.

3.3 Arrangement of on-site observation points

An important feature of this study is the participation in on-site teaching for the inheritance of intangible cultural heritage martial arts in universities. This is conducted through observation, recording, interviews, drawing, and other methods of on-site teaching. Therefore, determining observation points, introducing these points, and how to carry out systematic observation procedures have become key components of this study.

First, the determination of on-site observation points involved several steps. The first step was to determine the types, levels, geographical locations, and representative inheritors of Sichuan Province’s intangible cultural heritage martial arts using the China Intangible Cultural Heritage Network (China Intangible Cultural Heritage Digital Museum) and Sichuan Intangible Cultural Heritage Network. The second step was to determine whether the project had been practiced in universities or not by universities’ official website. The third step was to identify the level and name of universities in Sichuan Province through the official websites of the Ministry of Education and the

TABLE 1 List of interviews with inheritors of intangible cultural heritage martial arts universities.

Number	Gender	Inheritance project	Teaching methods	Identity of interviewee
CCR—F01	Male	National-level projects	Public physical education class	Representative inheritors
CCR—F02	Male	National-level projects	Leisure physical education class	Representative inheritors
CCR—F03	Male	Provincial-level projects	Public physical education class and martial arts professional class	Representative inheritors
CCR—F04	Male	Provincial-level projects	Public physical education class	Representative inheritors
CCR—F05	Male	Provincial-level projects	Public physical education class and extracurricular training courses	Representative inheritors
CCR—F06	Male	Provincial-level projects	Physical education elective course	Representative inheritors
CCR—F07	Female	City-level projects	Public physical education class	Representative inheritors
CCR—F08	Male	City-level projects	Public physical education class	Representative inheritors
CCR—F09	Male	City-level projects	Public physical education class	Representative inheritors

TABLE 2 List of interviews with teachers of intangible cultural heritage martial arts universities.

Number	Gender	Inheritance project	Identity of interviewee
GXJS—F1	Male	National-, provincial-, and municipal-level projects	University martial arts teacher
GXJS—F2	Male	National-level projects	University martial arts teacher
GXJS—F3	Male	National-level projects	University martial arts teacher
GXJS—F4	Male	National-level projects	University martial arts teacher
GXJS—F5	Male	National-level projects	University martial arts teacher
GXJS—F6	Male	National-level projects	University martial arts teacher
GXJS—F7	Female	National-, provincial-, and municipal-level projects	University martial arts teacher
GXJS—F8	Male	National-, provincial-, and municipal-level projects	Head of University Intangible Cultural Heritage Martial Arts
GXJS—F9	Male	National-, provincial-, and municipal-level projects	Retired university martial arts teacher
GXJS—F10	Male	National- and provincial-level projects	Head of University Intangible Cultural Heritage Martial Arts
GXJS—F11	Male	National- and provincial-level projects	University martial arts teacher
GXJS—F12	Male	National-, provincial-, and municipal-level projects	University martial arts teacher
GXJS—F13	Male	National-, provincial-, and municipal-level projects	University martial arts teacher
GXJS—F14	Female	National-, provincial-, and municipal-level projects	University martial arts teacher

government of the People's Republic of China. It should be noted that due to certain misunderstandings among universities regarding concepts such as intangible cultural heritage martial arts and inheritance, our preliminary field research led us to select specific universities conducting intangible cultural heritage martial arts teaching activities as our observation objects. In other words, universities chosen for observation must meet the following conditions. Firstly, there must be the teachers (inheritors) who are implementing in universities. Secondly, there must be a target audience (students) for inheritance of intangible cultural heritage martial arts. Thirdly, there must be specific teaching (or inheritance) activities. All three are indispensable, as shown in Figure 1.

Second, the on-site observation points were summarized. The first on-site observation point was Chengdu Sports University, one of the six sports colleges directly under the former General Administration of Sport of China. It is now a jointly established institution between Sichuan Province and the General Administration of Sport of China and is the oldest sports college in China. The school currently has over 9,300 full-time undergraduate students and over 1,300 doctoral and master's students. The school currently has over 1,200 in-service teaching staff, including over 600 full-time teachers and nearly 280 senior professional titles. Focusing on undergraduate education, the university has 21 teaching and research units offering 22 undergraduate majors spanning 7 university disciplines: education, medicine, literature, management, economics, art, and history. The school has first-level disciplines authorized for doctoral degrees in sports, as well as for master's degrees in sports, clinical medicine, integrated Chinese and Western medicine, and journalism and communication. There are also 14 second-level disciplines authorized for master's degrees, as well as four master's degree authorization points in sports, traditional Chinese medicine, journalism and communication, and art. The school established the Department of Martial Arts and Heavy Sports in 1959, the Department of Chinese Martial Arts in 1992, and the Martial Arts Academy in 2017. The martial arts college of the school has received many awards, including the National

Youth Martial Arts Routine Training Base and the Sichuan Intangible Cultural Heritage Research Base. The college's martial arts and traditional sports majors have been approved as characteristic majors, key disciplines, and national characteristic majors. The school established the Chinese Academy of Arts in May 2020 and was jointly designated as one of the first batch of provincial key Chinese cultural research institutes by the Propaganda Department of the Sichuan Provincial Party Committee, the Sichuan Provincial Department of Education, and the Sichuan Provincial Federation of Social Sciences. It aims to uphold and implement traditional Chinese culture in the country and Sichuan Province, focusing on building and promoting the Chinese spirit, reflecting the characteristics of Bashu, and jointly shouldering the historical mission of promoting excellent traditional Chinese culture with the school's martial arts academy. Emei martial arts and Zheng's martial arts are key projects in the curriculum construction of the school. Currently, two intangible cultural heritage martial arts projects have already been included in the undergraduate and graduate training systems.

The second on-site observation point was China West Normal University, a key provincial university in Sichuan Province, founded in 1946 and located in Huafeng Town, Shunqing District, Nanchong City. The school currently has 82 undergraduate majors, 19 first-level disciplines authorized for master's degrees, 13 categories authorized for master's degree programs, 6 disciplines jointly training doctoral students, and 1 postdoctoral innovation practice base. The school currently has more than 35,000 undergraduate, graduate, and international students. The school mainly focuses on teacher education, with over 2,700 faculty and staff, including over 1,000 teachers with senior professional titles and over 1,900 teachers with doctoral and master's degrees. The school has two campuses, one under construction, covering a total area of 4,000 acres. When Songxi Boxing entered the school in 2010, it went through two stages: inviting in and stabilizing. In 2010, Professor Zheng Zhigang from the School of Physical Education at West China Normal University invited Li Hanguang, a folk inheritor of Songxi Fist, to carry out extracurricular inheritance work at the school on weekends. The inheritance method of "please come in" continued until 2015. After 2015, Professor Wu Panwen from the School of Physical Education of West China Normal University carried out the inheritance work of Songxi Boxing in universities. Wu Panwen graduated from the Department of Biology at Qufu Normal University in 2002 and the School of Life Sciences at West China Normal University in 2006. After obtaining his master's degree, he worked in the Graduate Department of West China Normal University. During his studies in Nanchong, Wu Panwen studied under Huang Yanzhong, the 12th generation inheritor of the folk Songxi Boxing. He began to systematically learn Songxi Boxing and graduated with a PhD in Ethnic Traditional Sports from the School of Martial Arts, Shanghai Institute of Sports in 2015. After graduating with a PhD from the Shanghai Institute of Physical Education, he transferred from the Graduate Work Department of West China Normal University to the School of



Physical Education of West China Normal University to work in sports and martial arts teaching. He is a master's supervisor and also responsible for teaching martial arts in public physical education classes for ordinary college students. In addition, the school has established an intangible cultural heritage martial arts training base to carry out cultural inheritance and scientific research on Songxi Boxing for all teachers and students.

The third on-site observation point was Neijiang Normal University, which began offering higher education in 1956 and was upgraded to a university in 2000. The university covers an area of 3,115 acres and is a full-time undergraduate institution under the supervision of the Sichuan Provincial Government. The school is located in an important node city on the main axis of the Chengdu Chongqing Economic Circle. The school integrates graduate education (joint training), regular undergraduate and vocational education, continuing education, and international student education. It has 19 secondary colleges and 64 undergraduate majors, and currently has more than 17,000 full-time undergraduate and vocational students, international students, and graduate students. The school currently has 1,498 faculty members, 1,165 full-time teachers, 454 senior and associate professional titles, and 1,067 master's and doctoral students. The school was approved to establish the Sichuan Emei Martial Arts Culture Popularization Base in 2014, mainly focusing on the research of Emei martial arts culture education as well as the excavation, protection, inheritance, and promotion of Emei martial arts culture.

The fourth on-site observation point was Leshan Vocational and Technical College, located between Leshan Giant Buddha Scenic Area and Mount Emei. It is a double holy land of world cultural heritage and natural heritage, adjacent to the Qingyi River in Suji New Area. The school was established in 2002 by the Sichuan Provincial People's Government and Leshan as a comprehensive full-time public higher vocational college. It has a 70-year history of education and offers disciplines such as medicine and health, finance and tourism, machinery and electronics, and new energy. The school covers an area of over 800 acres, with over 600 faculty members and more than 14,000 full-time students. The school has a strong martial arts atmosphere, mainly through public physical education classes, specialized elective courses, and international students (Laos, Vietnam, and other countries) to carry out Emei martial arts. The teaching content mainly focuses on Emei Fist, and there are approximately 1,000 students participating in teaching activity.

The final on-site observation point was Chengdu Neusoft University, a private ordinary higher education institution approved by the Ministry of Education and funded by Neusoft. In 2021, it became the first university in Sichuan Province to pass the undergraduate teaching evaluation of ordinary higher education institutions. The school is located near Qingcheng Mountain 5A Scenic Spot in Dujiangyan Irrigation Project, covering an area of 528,500 m<sup>2</sup>. The school has 5 disciplines, namely engineering, literature, management, art, and medicine, 31 undergraduate majors, and more than 20,000 students. The national intangible cultural heritage martial arts project, Qingcheng Martial Arts, is an elective course at the university.

There are one or two classes per semester, with approximately 50 students in each class. The teaching content mainly focuses on Qingcheng Martial Arts Golden Knife Shedding and Qingcheng Tai Chi Health Preservation.

Thirdly, about the content and records of on-site observations. Given that on-site observations mainly involve individuals, events, and objects, the main focus of observation is on aspects such as content and methods of inheritance, venue facilities, student attitudes, and teacher-student interaction during teaching sessions. Observation not only includes the functional responsibilities, appearance, and language expression of inheriting and inheriting teachers, but also involves the teaching procedures of intangible cultural heritage martial arts, student physical practice, and interactive exchanges. At the same time, attention is given to public spaces, venue facilities, and equipment related to intangible cultural heritage martial arts teaching. Regarding recording methods, we ensured the completeness of teaching records to the greatest extent possible and adopted multiple parallel methods for recording. First, various shorthand methods were used to record the teaching site, and the entire process of teaching is recorded in the form of field diaries. Second, sound data from the teaching sessions were recorded through using recording equipment, and these recordings are promptly converted into text. Finally, the entire teaching process was filmed through using camera equipment and then timely transcribe the teaching process into text.

Fourth, the on-site observations were scheduled. The inheritance of intangible cultural heritage martial arts in universities is mainly based on regional martial arts, with a concentration of universities in Chengdu, Neijiang, Leshan, Nanchong, and other areas. They are relatively concentrated in the central area of Sichuan Province, with a distance of approximately 300 km between each university, and a total distance of approximately 1,024 km. This distance increased the difficulty for participation observations to some extent. As a result, the study started from Nanchong city, where the researcher was located. And the researcher used a car as means of transportation to travel back and forth between Nanchong, Leshan, Neijiang, and Chengdu, as shown in Figure 2.



FIGURE 2

Tour of observations on the inheritance of intangible cultural heritage martial arts universities.

### 3.4 Analysis and organization of research materials

This study involves various forms of data, including interview materials, on-site observation diaries, video and recordings, photographs, and activity materials. Therefore, significant time is required for data processing. Given the nature of these materials, the first step is to write an education log every day, documenting the materials seen and heard that day, and making notes and reflections on the materials during the writing process. Second, on-site recording materials, video materials, interview materials, and temporary conversations are transcribed to form written texts. Once again, it is necessary to review and code the text materials and create a memo during the coding process. Thematic coding is then used to classify the text materials and develop thematic analysis units. Finally, the paper is completed based on the thematic units. In the process of collecting, categorizing, analyzing, and writing, the memorandums of writing is always regarded as an important way to promote the next step of research. Through continuous reflection, the problems are formed and deepened. Ultimately, an educational ethnography was completed.

### 3.5 The identity of the researcher

In scientific research, the identity of researchers should be ignored as much as possible to enhance objectivity and reproducibility. However, in anthropological research, active participation in observation is important, which will inevitably impact the research scene and the researchers. Therefore, achieving the objectivity of observational data while ignoring the influence of researchers poses a challenge in field research. It is necessary to ignore the observer effect of researchers and achieve a true understanding of the research object. This study adopts the several measures to maintain a relationship with the subjects. First, before formal field investigations, researchers establish contact with the inheritors or university faculty who preserve inheritance. An interview is conducted first, followed by long-term communication to prevent discomfort to the inheritors or inheritors caused by unauthorized visits. This also narrows the distance between researchers and subjects, eliminating their guard mentality and encouraging a healthy relationship. For most universities, as martial arts belong to a common profession, there are many similar research topics, and there are no obstacles encountered when entering on-site teaching. Second, for universities that are familiar with inheritance teachers, they can enter through full participation in student training according to their training time. Third, due to the alumni relationship between the researchers and the inheritors of many universities in Sichuan Province, the identity of the researcher are referred to as “brothers” or “uncles” and “students”.

### 3.6 Trustworthiness for research

To ensure the richness and credibility of our data, we engaged in long-term participation with students between 2005 and 2024 during the research phase. In the writing stage, we used member checks to increase the credibility of the study. We provided participants with summaries of our analyses upon completion of the manuscript for feedback. To guarantee external validity, we used thick descriptions. Our research not only focused on positive examples, but also on negative ones to gain a deeper understanding of the problem. We used triangulation methods such as focus groups and documentary analysis, and described the project context, its characteristics, and the selection of participants.

### 3.7 Ethical considerations in research

In anthropological fieldwork, ethical considerations are also an important aspect, as the fieldwork involves deep-seated issues of human nature. As the research progresses, it is no longer a process of data collection, but involves issues such as people's emotions, attitudes, and values. Therefore, protecting the privacy of these individuals is crucial. This study adopts several measures to avoid ethical issues. First, before entering the field, active communication with the participants is undertaken to obtain their consent. Second, it is not necessary to make excessive value evaluations of the individuals' situation, but to interact and communicate with them as listeners. Once again, it is important to maintain an impartial attitude with the participant and not examine their behavior and cultural phenomena. Finally, in the writing stage, sensitive information related to the research participants will be processed in accordance with academic standards. Personal protection will be provided for the participants, and the role of researchers has been minimized.

## 4 Findings

Education plays an important role in shaping generations. “Education is a key means of enabling individuals to unleash their enormous inner potential, achieve supernatural transformation, establish effective connections between enormous needs and broad openness, and shape themselves correctly” (39). The curriculum content implemented in school education is the key to shaping an individual's future. Intangible cultural heritage martial arts is a body culture accumulated by the Chinese culture for thousands of years, so the martial arts contain profound survival wisdom and life experience. From the perspective of education's in shaping individuals, the inheritance of intangible cultural heritage martial arts in universities passes on the genes of China's excellent traditional culture. The people cultivated are those given the wisdom and genes of the Chinese culture, rather than those with other cultural attributes. Therefore, constructing the curriculum is the key to the inheritance of intangible cultural heritage martial arts in universities. In the case of Sichuan's



intangible cultural heritage martial arts, the focus is on simple and practical course construction, emphasizing basic skills and martial arts routines. Based on the specific situation of the inheritance of intangible cultural heritage martial arts in Sichuan universities, three types of curriculum construction have been formed: curriculum construction based on internal inheritors; curriculum construction based on external inheritors; and curriculum construction based on inheritance base construction.

#### 4.1 Construction of curriculum content based on inheritors on campus

There are two types of inheritors on campus: those who have a teacher-student relationship with intangible cultural heritage martial arts and those who are ordinary martial arts teachers. For inheritors with a teacher-student relationship, more emphasis is placed on simplifying the original content to make the inherited content more suitable for the physiological characteristics of students. On the other hand, ordinary martial arts teachers mostly choose representative intangible cultural heritage projects as inheritance content. For example, take the inheritor of Songxi Boxing, who has a teacher-student relationship. When the inheritors taught the Songxi Boxing in universities, they did not completely copy the content and teaching mode of the folk. Instead, they reorganized and rearranged the content according to the specific situation of the university. They simplified the contents such as boxing, sword, and tiger tail whip, and they changed the originally complex content into a clear hierarchical routine system. From the several martial arts routines currently taught, it can be seen that Songxi Boxing has significantly simplified the content. Why does Songxi Boxing require a simplified routine? CCR-F01, an inheritor of Songxi Boxing at a university, explained it this way: “In the past, I had a lot of practice content, but it was very tiring, and now I don’t teach it this way. Some types of boxing are not recorded in that book (“Songxi Neijia Boxing”) (31 October 2021, Field Diary, CCR-F01).

The simplification and creation of routines is not simply a random combination of routines, but a reintegration and innovation based on the original martial arts, aimed at preserving the core techniques of Songxi Fist. In other words, although Songxi Boxing selects course content through simplified routines in the inheritance of higher education, these routines are the core technologies of the boxing genre. In this sense, the simplified routine does not deviate from the tradition of Songxi Fist, but it undergoes a series of simplification and experimentation processes. For the simplified process of Songxi Fist, the CCR-F01 said, “Songxi Fist Enlightenment Fist was created with great effort by Master Huang and me” (24 October 2021, Field Diary, CCR-F01) and “Songxi Guiyi Fist was created by Master Huang and me. When I was practicing, Master Huang decided which action to use, and thus became the current Guiyi Fist routine” (19 June 2022, Field Diary, CCR-F01).

These created Songxi Fist routines are not created arbitrarily without proper organization, but on the basis of ensuring a certain connection between fists, which facilitates the transfer of

movements between different types of fists and preserves certain similarities in movements between routines. At the end of a training session, the inheritance teacher revealed the connection between routines: “Enlightenment Fist and Guiyi Fist are a progressive process, and many movements are reflected in the two types of punches. The Songxi Fist routine we are practicing now is based on the previous one, which used to have a lot of repetitive content. Now, we have deleted these routines. The reason why the previous routines were complex was because they were taught to students in the past. Waiting for students to practice is a tuition fee, and if it’s too simple, it won’t attract students, so the routine is made up very long. The current routine is not specifically designed for charging” (31 October 2021, Field Diary, CCR-F01).

Creating routines is challenging, as each action needs to be carefully selected to better reflect the technical style of Songxi Fist. Despite this difficulty, it is important that the created routines are understandable not only to the veteran boxer himself but also to others. “The Harrier Fist is the most comprehensive routine, almost including all the movements of the Songxi Fist, and the requirements for footwork are not strict. The Harrier Fist can only be understood by experienced boxers, and was given a low score by the referee when participating in competitions” (19 June 2022, Field Diary, CCR-F01). Based on ensuring the created routine can be understood, the primary goal is to facilitate the teaching of college students, helping them to get started. The inheritance teacher said, “The Songxi Enlightenment Fist had an introductory routine before, and during my teaching, I felt that this routine was not like an introductory routine” (3 July 2022, Field Diary, CCR-F01).

Before the creation of the Songxi Enlightenment Fist, the Songxi Six Step Fist was used as an introductory routine. This routine has long and difficult movements, making it difficult for students to master in inheritance. After the creation of the Songxi Enlightenment Fist, it became an introductory routine for Songxi Fist. The movements are relatively simple and more suitable for new students to learn. In terms of the difficulty of the above two routines, students need to complete one semester to master Songxi Six Step Fist, while the current Songxi Enlightenment Fist can be mastered in half a semester. The decision to simplify these routines came from the “awkwardness” experienced by practitioners in the early stages of training. Because the inheritors of intangible cultural heritage have practiced competitive martial arts before practicing Songxi Boxing, they clearly feel uncomfortable when transitioning to Songxi Boxing. The stark contrast between traditional and competitive martial arts highlighted the need to resolve the “awkward” issue of Songxi Fist. After a training session, the inheritor teacher also had a discussion with the author specifically about the “awkward” problem of Songxi Fist. The inheritor teacher also said, “I have practiced competitive martial arts and some other traditional routines before, but I always feel awkward when practicing Songxi Fist” (30 October 2021, Field Diary, CCR-F01).

To test the effectiveness of the newly created boxing techniques, the inheritors of intangible cultural heritage martial arts conducted special competitions experiments using the

simplified boxing routines. These achieved satisfactory results in the competitions. The inheritor said, “The Guiyi Quan that the advanced class is practicing now is a very good boxing technique. I have tried it twice in competitions and achieved good results each time. Now, I don’t want Songxi Quan to participate in competitions, so it requires difficult movements, with each difficulty given a point. Many traditional boxing techniques are now taking the path of competitive techniques, but Songxi Quan does not. It has always adhered to traditional things. If students make some competitive movements during practice, I will be corrected Come here” (On 30 October 2022, Field Diary, CCR-F01). The competition experiment mentioned by the inheritance teacher was for martial arts routines for college students in Sichuan Province in 2018 and 2019. Students achieved good rankings in the competition, and the simplified teaching effect was well verified.

There is a fundamental difference between the routine creation and folk creation of Songxi Boxing. There is a mutual connection between different types of boxing, which not only reflects the style characteristics of boxing, but also preserves the core techniques of boxing. From beginning to end, there is a strong coherence, and the techniques are more like a series of attack and defense movements in a technical attack. For example, how to attack the first action, when the enemy escapes, followed by the pursuit of the second action, and so on; the technical attacks are intertwined. In terms of preserving the technical style, each technique originates from the ancient techniques of Songxi Fist, or techniques using the Songxi Fist style are selected for creation. In terms of style, Songxi Boxing effectively protects the style of boxing in the inheritance of higher education, which is a further refinement of core techniques. As explained by the inheritor of intangible cultural heritage martial arts, “Songxi Guiyi Fist is quite classic, and I have also shown it in other places. Others wanted me to teach it, but I did not. He said that only Xihua Normal University has the Songxi Guiyi Fist, and there are no other places” (26 February 2022, Field Diary, CCR-F01).

Maintaining the original flavor of traditional martial arts is a major challenge in its development and has always been a focus of debate in various fields. Some people even have doubts about how intangible cultural heritage martial arts can maintain their original flavor. As for the creation of Songxi Boxing in universities, they are more focused on refining the core techniques of their martial arts, and the style of their martial arts has not changed. In this sense, the core technology is the original flavor of the boxing, which breaks through the narrow understanding that the boxing must remain the same as the original boxing. Qiu Pixiang once mentioned the issue of core techniques in traditional martial arts in an interview, emphasizing the need to leverage the “corner” of traditional martial arts, which emphasizes the core techniques and techniques of traditional martial arts (40). Songxi Boxing embodies the original inheritance concept by retaining the style of its core techniques. It is worth noting that although inheritors in universities attach great importance to the preservation of the core skills of Songxi Boxing, intangible cultural heritage martial arts inevitably change with the habits of different practitioners.

Students will make certain adjustments during practice based on their habits, bodily sensations, and other factors. Therefore, it is necessary to approach the issue of the authenticity of boxing with rationality. Undoubtedly, retaining core technologies is an effective way. This is also where the inheritance teacher is very satisfied and proudly says, “Only China West Normal University can have the return to one fist.” Therefore, the classicism of Songxi Fist is not entirely authentic, but it can still achieve maximum modern innovation, and the created routines have also been recognized by others, which means achieving the integration of tradition and modernity. Innovation itself is the process of constantly refining essence, and the classic style of boxing should also be considered. Creation itself is art: “Songxi Guiyi Boxing is an adaptation of the existing 11 sets of movements of Songxi Boxing. We are thinking about those movements every day. Songxi Boxing not only has offensive and defensive skills, but also has some solutions.” “By practicing Songxi Fist, one can better evaluate other punches. In comparison, after practicing Songxi Fist, one does not want to watch other punches” (5 March 2022, Field Diary, CCR-F01).

This highlights that the martial arts routines of Songxi Boxing in university inheritance are not the result of random patchwork, but rather a combination of all the classic movements of Songxi Boxing. It also shows that the attack, defense, and solution of Songxi Fist have been preserved. In this sense, “professional things should be done by professional people” is a very appropriate description of the creation process of Songxi Fist. The practice of randomly creating routines online has been criticized by inheritors. The inheritor said, “I have a friend in Wudang Mountain, where there are also many practitioners of Songxi Fist, but they are all just superficial and learned online. We don’t know the connotation of Songxi Fist, but we are different here. We explain every action very clearly” (5 March 2022, Field Diary, CCR-F01). To ensure the classic nature of the martial arts and the authenticity of the inheritance content, the number of inheritors who will pass it on are the key considerations of inheritor teachers. However, the inheritance teacher said, “Only a small number of people are passing the Guiyi Fist, and they don’t want to pass it on a large scale. The number of people should not exceed 10, and there will be various conflicts when there are more people. That is not to say Songxi Fist is conservative, but I’m afraid that some people in the folk will randomly arrange for economic benefits after learning it. Some people will lose out in competitions because there is no difficulty, so many people have changed their movements in order to participate in competitions. We only inherit these things in universities, and outsiders will definitely not learn them” (21 May 2022, Field Diary, CCR-F01).

For inheritors of intangible cultural heritage martial arts in universities, the inheritance of Songxi Boxing does not depend on numbers, but on having trustworthy students. This is also a difference between university inheritance and folk inheritance. In the folk tradition, what may be contested is of economic value. If it is advantageous, it can be taught, even if it destroys the original appearance of the martial arts. However, in universities, inheritors will preserve the original appearance of the martial

arts in a new form and pass it on to students. In universities, the inheritance of martial arts routines by inheritance teachers is determined by the learning capacity of college students. Students cannot learn dozens of martial arts routines within a limited period, nor do they have the energy and time to do so. The creation of this routine can be seen as innovation from inheritance teachers, integrating dozens of tedious routines into one routine, ensuring its smooth inheritance in colleges and universities. Although the routine is not the original one, it retains the essence of Songxi Boxing.

## 4.2 Curriculum content construction based on extracurricular inheritors

From an educational anthropology perspective, local textbooks are important curriculum resources for educational implementation, and can be transmitted via principles such as “cognition, emotion, social identity, and individual cultural adaptation” (41). Intangible cultural heritage martial arts exist more as local knowledge and belong to a local cultural tradition, thus possessing the characteristics of local curriculum resources. However, they are heavily based on the characteristics of the boxing styles and personal cultivation of the inheritors. Compared to the course content chosen by university teachers on campus, the construction of content based on external inheritors is more distinct. The construction of course content is based on hot topics such as martial arts, students’ abilities, and course continuity. For example, when inheriting Qingcheng martial arts in universities, the focus is on its local cultural characteristics. CCR-F03, the national inheritor of Qingcheng Martial Arts, introduced the entire process of constructing the content of Qingcheng Martial Arts curriculum: “We hope that college students can feel the traditional culture. When they arrive at Qingcheng Mountain, they can practice Qingcheng Wushu, and feel the local culture. For college students, cultural confidence and cultural identity are still helpful in various aspects. Their school is dedicated to sports such as running jump shots every day, or athletics or track events, which may not be very rich or relatively simple, while martial arts are relatively supplementary” (12 January 2023, Field Diary, CCR-F03).

Human ecologists believe that “humans are influenced by the environment, and at the same time, they also influence the environment, which is achieved through interdependent systems formed between humans, the natural environment, and members of society” (42). The ecological environment requires more human creation, because students have a short time in school. Even if they are in a specific cultural environment, it is difficult for them to perceive regional culture. However, by creating specific cultural scenes and offering reasonable guidance, students can better understand regional culture. The introduction of Qingcheng martial arts into universities is to guide local culture, create a cultural inheritance environment, and encourage students to better understand intangible cultural heritage martial arts, enabling them to promote culture. So why do inheritors of intangible cultural heritage martial arts emphasize the importance

of regional culture? After further research, we know that the universities do not lack sports projects or martial arts related teaching content, but rather lack curriculum content with local characteristics. The regional cultural characteristics are the competitiveness and advantages of Qingcheng martial arts. “For ordinary martial arts, there are more students. But our martial arts are a supplement to local culture, or a supplement to martial arts culture. After all, you are in Qingcheng Mountain in Chengdu. It may also represent a local culture, not just competitive martial arts. Competitive martial arts, as mentioned earlier, are very good. Its main focus is on competition, and we emphasize cultural development” (12 January 2023, Field Diary, CCR-F03).

As a form of local knowledge, intangible cultural heritage martial arts reflect more of the local culture, which is also an important value for its entry into university inheritance. It can fill gaps in mainstream educational knowledge, and this is also a cultural advantage. From an anthropological perspective, education is a broad concept that not only includes school education, but also informal learning, such as family education and social education. It is not only a comprehensive forms of education, but also a broad educational attitudes. From this perspective, family or social education does not impart knowledge to students through fixed class hours, but through customs, physical experience, and even myths, legends, and stories. Intangible cultural heritage martial arts have educational value because they contain survival experience and wisdom with regional customs and traditions, and are cultural traditions accumulated within a local scope. Therefore, the inheritors of intangible cultural heritage martial arts are very proud to say “as a supplement to local culture.”

When the inheritors of intangible cultural heritage martial arts understand the importance of local culture, the dissemination of local knowledge becomes the main focus of content construction. Specific inheritance content will then be selected based on the school’s circumstances. In the construction of the inheritance content of intangible cultural heritage martial arts in universities, it is not about blindly choosing one or two routines as course content, but about making content choices based on the school’s specific educational environment. This mainly depends on the students’ interests, learning hours, and their training goals. The inheritor of Qingcheng Martial Arts described the main factors to consider when choosing inheritance content and gave a vivid example of course selection: “It is unrealistic for students to learn a lot of things for 32 h in a semester. I think Tai Chi is very practical. My students at the School of Business are in the leisure and sports field, and most of them come out in professions related to sports, tourism, and leisure sports. The graduate needs leadership, team building, and the health group around him. There is a greater demand in society for Tai Chi, so they can use Tai Chi activities during team building. The classes here were quite tight, I used a short fist and a set of short Tai Chi to let them all feel it. Because they are not professional learners after all, so I combine this fact, martial arts and Tai Chi are half and half. I let them fully experience the characteristics of Qingcheng Mountain martial arts, he can strengthen his physical fitness, and



after working in society, he can have some applications" (12 January 2023, Field Diary, CCR-F03).

The inheritors of intangible cultural heritage martial arts are extremely cautious in constructing inheritance content in universities, which is also an extremely complex cultural decision. They must consider various aspects, including the nature of the curriculum, student interests, practicality, students' martial arts foundations, and employment requirements before finalizing the inheritance content. The construction of content for the inheritance of intangible cultural heritage martial arts in universities is a targeted cultural selection process, aimed at providing tangible benefits to students. Given the limited time students have to practice in universities, usually just one semester, it is not realistic to arrange excessive teaching content.

*"Simplicity and practicality" have become the basic principles followed in the inheritance of intangible cultural heritage martial arts in universities. When constructing the inheritance content of intangible cultural heritage martial arts, it also focuses on some hot topics, such as explaining topics that students are interested in, answering social hot topics that students are concerned about to alleviate students' misunderstandings of martial arts, and correct their biases towards Chinese martial arts. I will not only teach a set of punches. Actually, the culture is very important behind the skills. I will break down each action and explain to him how the technique is used. Of course, I will always emphasize that it's not about letting you know and then fighting or trying. I hope you understand this culture. The difference between martial arts and dance, as well as acrobatics, lies in the meaning of offensive and defensive techniques. Otherwise, what is the difference" (12 January 2023, Field Diary, CCR-F03).*

Intangible cultural heritage martial arts are also traditional martial arts in essence, and the martial arts are the basic premise of its existence. However, the inheritors of intangible cultural heritage martial arts do not only consider its martial arts. They also explain the cultural significance behind the intangible cultural heritage martial arts actions to students, so that they can understand it from a broader perspective. From a cultural perspective, it is important to help students understand that intangible cultural heritage martial arts not only focus on fighting, but also reflect traditional Chinese culture. From a cultural cognition perspective, students mainly rely on fragments of new media networks to learn the intangible cultural heritage martial arts; thus they do not have a deep understanding of it, and they often cannot discern malicious events on the Internet. Therefore, as inheritors of intangible cultural heritage martial arts, they must clarify online misconceptions to students from a more professional perspective, which can resolve various misunderstandings about intangible cultural heritage martial arts. Explaining offensive and defensive techniques realistically without exaggeration can establish an understanding of the principles of martial arts for students.

Technical combat is an essential part of Chinese martial arts; however, after the use of cold weapons, the functions of Chinese

martial arts have undergone significant changes. The question of whether Chinese martial arts can fight has become a social issue. In addition, with the hype of various online content, the stigmatization of Chinese martial arts "flower boxing and embroidered legs" has been infinitely amplified, so the stigmatization added the negative portrayal of Chinese martial arts. In this context, as disseminators of intangible cultural heritage martial arts in universities, it is natural for inheritors to teach the correct concept of martial arts to students, so that they can calmly view the issue of "no fighting" in Chinese martial arts. This also fully demonstrates that the inheritor of intangible cultural heritage martial arts is not only a disseminator of Chinese culture, but also a legitimate shaper of Chinese cultural concepts. Therefore, when constructing the content, they firmly choose to be a correct defender of Chinese martial arts culture.

This shows that this is a result of the interweaving of diverse values, which also indicates that the inheritance concept of intangible cultural heritage martial arts in universities has undergone profound changes. The inheritance of intangible cultural heritage martial arts in universities is not only a superficial technological development, but also an awakening of cultural functions. In addition, inheritors of intangible cultural heritage martial arts have also seen that they should not only focus on advanced academic theories, but also they should engage with reality and keep up to date to ensure cultural vitality.

#### 4.3 Course content construction based on base construction

In addition to using both on-campus and off-campus inheritors to construct content, there is also a "school local cooperation" curriculum model for the inheritance of Sichuan intangible cultural heritage martial arts universities. This model requires the integration of local intangible cultural heritage martial arts resources to determine its specific curriculum content. Particularly in universities with official national approval and licensing, curriculum content is often determined by integrating on-campus and off-campus projects at all levels (including national, provincial, municipal, district, and county levels). Some universities may even condense one to two sets of school-based curriculum resources in dozens of intangible cultural heritage martial arts projects, forming a complementary curriculum of "off-campus resources" and "school-based resources." Compared with the curriculum construction methods above, this model plays a decisive role on base construction, influencing content selection, determination, implementation, and evaluation. However, the inheritors of intangible cultural heritage need to construct the curriculum content in a complex power structure. Universities with a focus on "base construction" first need to meet the needs of their own inheritance bases, complete various university cultural inheritance base tasks, and meet the review requirements from relevant approval departments. Therefore, curriculum construction has multiple values and is also relatively complex. As a result, curriculum construction based on the inheritance model of intangible cultural

heritage martial arts university inheritance bases has higher requirements. When selecting and determining course content, not only are collective efforts needed, but various inheritance resources need to be considered both on and off campus.

Specifically, the curriculum content inherited by Sichuan's intangible cultural heritage martial arts universities focuses mainly on local martial arts, especially on its inherent cultural value. For example, Neijiang Normal University hires inheritors as visiting professors who are inheritors from the national, provincial, and municipal levels. However, due to the time constraint, there requirements for the construction of curriculum content in intangible cultural heritage martial arts are limited. The time constraint prevent the universities to simultaneously teach all of the martial arts activities beyond intangible cultural heritage. Therefore, only the historical origins of intangible cultural heritage martial arts are taught. "I was sitting down to talk about theory. The first class talked about the history of our Peng Family Boxing, how it came about and how it was passed down" (On 9 January 2023, Field Diary, CCR-F07).

Another inheritor of intangible cultural heritage martial arts at the city level has also been invited by the school to be a visiting professor and teach the theoretical content related to martial arts: "The school calls us to give lectures, and each sect teaches according to their own sect. The martial arts of our sect are different from each other. Our sect and other sects are giving lectures, which are divided into two parts. In the classroom, there are cultural lectures, and each sect teaches different things, such as origin, characteristics, and inheritance" (On 10 January 2023, Field Diary, CCR-F08). This shows that the curriculum content construction mainly focuses on explaining the school's origin, inheritance, and characteristics; however, this construction is also the result of a joint discussion between the school and the inheritors. From the universities' perspective, the inheritance of intangible cultural heritage martial arts should mainly emphasize cultural inheritance, rather than imparting intangible cultural heritage techniques. Inheritors of intangible cultural heritage martial arts choose these contents because curriculum construction is determined by the school's cultural regulations and teaching methods. Multimedia classrooms naturally focus on theoretical teaching, and the history of boxing is the best choice. Another reason is that the inheritors of intangible cultural heritage martial arts are older and have difficulty demonstrating movements, making theoretical teaching a better way to leverage the cultural advantages of intangible cultural heritage martial arts. However, in curriculum construction, the emphasis is on highlighting the characteristics of the martial arts genre. For example, in the teaching of Wude, the inheritors have strong characteristics of the martial arts genre through the form of four songs:

*"I started with four songs in class. The first is the song of apprenticeship, the second is the song of practice, the third is the song of thugs, and the fourth is the song of martial arts. Actually, we only attended one class at the teacher's college. We only took one class for inheritance, and we only needed one class to pass on our sect. Each sect has actually gone there only twice, and we have only gone there twice. Because you*

*have too many traditional martial arts, you need to influence other formal courses. If you want to learn from various schools of martial arts, such as Xingyi Quan, Pengjia Quan, Wangjia Quan, Huangjia Quan, and Xiaolong Quan), it will inevitably affect its teaching, and you don't have time to arrange it. Therefore, it is impossible for it to go in large numbers"* (On 10 January 2023, Field Diary, CCR-F08).

However, due to the limited number of class hours allocated to intangible cultural heritage martial arts in universities, curriculum construction can only provide students with brief insights. The inheritors of intangible cultural heritage martial arts believe that they cannot influence other martial arts courses (such as Tai Chi, competitive martial arts, Changquan, etc) in universities during their appointment. In addition, some universities have introduced numerous intangible cultural heritage martial arts projects, resulting in most inheritors having only two classes scheduled, all taking the form of theoretical courses. Only a few boxing styles have more teaching time scheduled because their cultural system is relatively complete, and their inheritors also have a high reputation in the martial arts industry or the local area. Inheritors of intangible cultural heritage martial arts express concerns about class hours, because the universities offer other martial arts courses in addition to intangible cultural heritage martial arts, and these courses should be the mainstream curriculum. So, the entry of intangible cultural heritage martial arts should not affect the mainstream curriculum. This shows that the construction of course content depends on the mutual recognition between universities and inheritors. On one hand, some intangible cultural heritage martial arts have a complete boxing system and high educational value; therefore, inheritors are unwilling to bring this system to universities for instruction. On the other hand, universities do not have a deep understanding of intangible cultural heritage martial arts and cannot recognize their cultural significance. They will not introduce intangible cultural heritage martial arts into universities, and schools focus more on the cultural style of martial arts. In the construction of course content, universities view the introduction of intangible cultural heritage martial arts into universities as mainly cultural inheritance, representing traditional Chinese culture. Most importantly, some inheritors of intangible cultural heritage martial arts believe that the characteristics of boxing should be reflected:

*"The school turns us into professors and visiting professors, and then allows each sect to conduct so-called field investigations. The aim was to tell the students: Do you know which martial arts schools and characteristics there are in here? So each inheritors was to talk about the characteristics, styles, origins, and so on. It's impossible to talk about things like Tai Chi, Xingyi Quan, because it's a big school. If you talk about it again, you'll just draw a snake and add more feet. You don't have any unique features"* (On 10 January 2023, Field Diary, CCR-F08).

Higher education institutions attract a large number of students; they are also centers for cultural exchange between different regions in China and even internationally. However, for students, this knowledge is unsurprising and uninteresting. Therefore, the requirement for intangible cultural heritage martial arts is a unique cultural style to supplement universal culture from the perspective of cultural specificity. As the inheritors of intangible cultural heritage martial arts have said, “Tai Chi and other major schools are like adding to the snake’s feet without any distinctive features.” This also reflects the universities’ cultural preferences in constructing the content of intangible cultural heritage martial arts content. In addition, content selection based on base construction not only focuses on the cultural characteristics of intangible cultural heritage martial arts in curriculum construction, but also meets the needs of base construction.

*“Let me tell you the higher school how to operate. Firstly, it hires more experts in intangible cultural heritage as guest professors and categorizes them to explain cultural aspects. When the students can’t even understand horse stance, bow stance, and rest in public physical education classes, the university calls the city level intangible cultural heritage inheritors to teach. If the classes are important, the school will let me, a master level person, give it public physical education classes. There are many students, and hundreds of students will take part together. The school will take photos and take photos. The main purpose is to provide materials to meet the scrutiny of several brands. Without these, the school cannot achieve its current scale in martial arts” (On 9 January 2023, Field Diary, CCR-F06).*

“Classifying teaching” is a fundamental principle in content construction to meet the needs of students at different levels. However, due to the fact that intangible cultural heritage martial arts are mainly based on regional martial arts, students in both professional and public sports classes are not familiar with intangible cultural heritage martial arts. Compared to students in public sports classes, students in professional classes have a certain foundation in martial arts and are more likely to complete their movements. Therefore, universities will use intangible cultural heritage martial arts as a supplement to professional classes. For students in public physical education classes, due to the large number of students and the large settings, only master level individuals can meet the needs of this inheritance. Because master level individuals are knowledgeable and experienced, they will make timely adjustments based on the specific situation of the students. More importantly, master level individuals can simplify the complex content of intangible cultural heritage martial arts and allow students who have never practiced or been exposed to martial arts in these public sports classes to better understand the content of intangible cultural heritage martial arts. For example, complex traditional martial arts concepts, such as meaning, Qi, and martial arts can be explained to students in just a few words by master level inheritors, while ordinary inheritors of intangible cultural heritage martial arts lack the ability to summarize and simplify

these concepts. From this perspective, the construction of intangible cultural heritage martial arts inheritance content primarily based on base construction is a comprehensive consideration of the inheritor’s ability, teaching objectives, and school requirements. This also reflects the complexity of curriculum construction in the intangible cultural heritage martial arts universities. It can be said that such universities are more complex in content construction because they do not fully accept the inheritance content of intangible cultural heritage martial arts, but rather adopt a “critical absorption” and “resource integration” approach. An in-service martial arts teacher from a martial arts university evaluates the inheritance content of intangible cultural heritage martial arts as follows:

*“We will turn intangible cultural heritage projects into a book as a tutorial. Just to say, the first step was to refine these intangible cultural heritage movements. The second step was centered around XX Fist, and then combined with other martial arts to add it up. If you were to focus solely on each intangible cultural heritage fist type, it would be too much. There are seven or eight schools, and class hours are not allowed. In this way, we have refined them for the sake of inheritance and promotion. Each of their fists has its own characteristics, as well as its own essence, and there are many repetitive movements. Both in terms of content and layout, they are not very clear, so they are passed down through this refinement method. Inviting the inheritors to come is definitely very grateful to them, but we cannot simply promote one. The inheritance must take its essence, discard its dross, and carry out inheritance. Only in this way can there be development and innovation. Only through innovation, improvement, and development can your boxing be inherited and promoted. The integration of intangible cultural heritage martial arts has been recognized by the inheritors of intangible cultural heritage martial arts. We will always cooperate with the inheritors of intangible cultural heritage, not that we will ignore them. No” (On 11 January 2023, Field Diary, GXJS-01).*

School education is a public temporal and spatial field for carrying out educational and inheritance activities; however, the spatial and temporal attributes of the public activity field will not change. In a constant temporal and spatial field, coordinating diverse educational resources is important. On one hand, universities with these rich educational resources should consider a balance between martial arts from on and off campus, rather than favor a particular genre. Therefore, universities adopt the approach of “extracting the essence” to highlight the “innovative” inheritance of intangible cultural heritage martial arts by deleting the repetitive actions in some boxing styles and extracting the essence from various schools. However, this also highlights the powerful role of curriculum content construction in inheritance of intangible cultural heritage martial arts universities. At the same time, it also shows that universities regard competitions as a criterion for evaluating the quality of intangible cultural heritage by placing intangible cultural heritage martial arts in the current field of competition and testing their efficacy. This shows

that the inheritance content of intangible cultural heritage martial arts has been re-refined by university martial arts teachers to form their own curriculum systems. The above is only a preliminary screening in the construction stage of inheritance content. After teaching, university teachers will also conduct in-depth analyses of the inheritance content of intangible cultural heritage martial arts in universities for students. The purpose is to help students re-understand the inheritance content of intangible cultural heritage martial arts according to the competition rules:

*“The inheritors of intangible cultural heritage martial arts teach their own. But later on, we will explain to the students how to dissect this movement. You need to give them guidance, and tell the students how to appreciate and appreciate it. The routine did not change technically, but I changed my requirements. It means that the inheritors of intangible cultural heritage martial arts are not God. We will tell students not to change their style and content, but to make demands, such as the requirements for strength and rhythm, and how to reflect them in terms of spirit. If the inheritors of intangible cultural heritage martial arts talk about the meaning of attack and defense, I will explain why they did this action, where the meaning of attack and defense is, and how to express it. That is to say, after leaving you, I want to promote it and must require students to do it according to the current requirements. In competition, If I wanted to achieve good results, I had to practice according to the rules. I went to the competition a few times and followed the rules and requirements to do it. As an athlete, I have to adapt to this rule” (On 11 January 2023, Field Diary, GXJS-01).*

This demonstrates that the inheritors teach students “authentic” intangible cultural heritage martial arts; however, university martial arts teachers also need to conduct a “secondary analysis” according to the rules of martial arts competitions, and “re-examine” the inheritance content of intangible cultural heritage martial arts inheritors to ensure it meets the requirements of these competitions. In this context, martial arts teachers in university are like “football goalkeepers” or “a filter.” They re-screened the intangible cultural heritage martial arts according to specific competition rules.

Although the original ecology of the inheritance content in intangible cultural heritage martial arts universities may undergo certain changes under specific conditions, the inheritors of intangible cultural heritage martial arts adhere to the preservation of the unique style of boxing. The inheritor of Songxi Fist, a provincial-level intangible cultural heritage project, regards maintaining the style of the martial arts as the original intention of university inheritance, and believes that the construction and explanation of inheritance content must be vivid. “If you want to go to school for inheritance, regardless of any martial arts, you need to retain your unique style of the martial arts. Firstly, it must have a coherent history, and secondly, it must have unique characteristics of the sect. You need to embody the essence of tradition. When entering school, you must inherit tradition, which is a prerequisite and the overall

direction. The first is the truth, and the second is the key. Students should be willing to listen, and all your theories need to be combined with practice” (11 January 2023, Field Diary, CCR-05).

A distinct boxing style is the soul of any boxing sect. Particularly for intangible cultural heritage martial arts, highlighting the style of boxing is key to the development of boxing. Without a unique style, any boxing form will eventually be assimilated by other boxing styles. Regarding the inheritance of martial arts in universities, the lack of style in martial arts means a lack of cultural characteristics. It also means that the general sense of culture cannot meet the role of cultural supplementation, so there is no need for universities to introduce it. Because the general culture is familiar to everyone and lacks its own characteristics. That is to say, the boxing style represents the cultural charm of intangible cultural heritage martial arts, which is not just a superficial disguise or forgery, but has a cultural foundation emanating from the bones of boxing. From a cultural perspective, any intangible cultural heritage martial arts project has core skills that have been passed down through generations. These core memories can span time and space, forming the style of the martial arts genre, and are iconic skills that distinguish between martial arts genres. Any inheritor of intangible cultural heritage martial arts is a spokesperson for the style and characteristics of the martial arts genre. Therefore, regardless the changes in transmission methods, they always adhere to the style of the martial arts genre and uphold its “traditional coherence and unique style.”

Although maintaining the style of intangible cultural heritage martial arts boxing is a basic concept for inheritors in university settings, it does not mean that the more profound the boxing, the better. The depth of boxing style or theory does not necessarily represent the quality of intangible cultural heritage martial arts university inheritance. On the contrary, the strategy adopted by inheritors of intangible cultural heritage martial arts in the construction of inheritance content is to “avoid the heavy and neglect the light,” eliminate the profound and difficult to understand content, and teach some universally applicable boxing principles, so that students can “learn” and “understand” them at a glance. Essentially, whether it is intangible cultural heritage martial arts or another combat technique, it is a technical means of using the body to produce significant impact through the reasonable coordination of the hands, elbows, shoulders, feet, legs, hips, and other bodies. Inheritors compare and create connections of this technique in the selection of inheritance content to enable students to have a simpler understanding of the principles of intangible cultural heritage martial arts. However, this does not mean that intangible cultural heritage martial arts have lost their characteristics, but rather indicates that the inheritors have a broad perspective and the ability to distinguish differences from similarities. Therefore, as stated by the inheritors of intangible cultural heritage martial arts, “not only should the movements be standardized, but also able to be used”; “practice for use” reflects the practical thinking in the inheritance of intangible cultural heritage martial arts in universities. This is also a key factor that inheritors of intangible cultural heritage martial arts should consider when selecting inheritance content. The inheritor of



intangible cultural heritage martial arts narrated the teaching scenes of martial arts in universities, which can be said to be “unique,” and gave students a live demonstration of “whether traditional martial arts can be fought”:

*“I talked for an hour, about ‘last come, first served.’ In layman’s language, it is called defensive countermeasures. I said you are all professional classes, including practicing Taekwondo, martial arts, and Sanda. ‘Come out a few people and have a fight with me.’ Four people were called up. A sanda student who is 1.8 m tall. I said whatever you want to do, I won’t shout for your left foot. As soon as he stepped out, I charged in and took a step in. I shrugged and exerted force, knocking him down. Sprinkle and fall to the ground, fly into the crowd and sleep (lie down with four feet facing the sky). Then, I said ‘come and go,’ then another three students won’t come and immediately return to their positions and sit up” (11 January 2023, Field Diary, CCR-F05).*

Intangible cultural heritage martial arts are a form of expression for body techniques, acting as symbols representing culture. Therefore, it is only through this immersive on-site teaching that students can truly appreciate the charm of this physical technique. One reason why the inheritors of intangible cultural heritage martial arts emphasize the combat effectiveness of these techniques is partly because the boxing technique itself has strong combat effectiveness. Although the late start system reflects the common combat methods in traditional martial arts, the practical teaching of specific boxing techniques can better enable students to experience the charm of boxing. On the other hand, due to the personalities of the inheritors, this teaching method better reflects their characteristics. Another aspect is that the traditional martial arts have been heavily influenced by negative connotations, and the inheritors have used this to prove the strong style of traditional martial arts. These factors collectively contribute to the practicality of how inheritors of intangible cultural heritage martial arts select and explain inheritance content. This way, students can at least experience the combat attributes of traditional martial arts.

## 5 Discussion

Based on the above results, it can be concluded that the following characteristics in the inheritance of intangible cultural heritage martial arts in universities are worth further discussion.

### 5.1 Highlighting local knowledge of cultural heritage

Local knowledge, a concept pioneered by contemporary American anthropologist Clifford Giltz, has had a profound impact on various fields, including philosophy and linguistics (43). Local knowledge and universal knowledge are corresponding concepts; the former highlights the local characteristics of

knowledge system construction and has a strong substantive color, while the latter emphasizes the universality of knowledge system construction, representing formal thinking. In this sense, local knowledge emerged from the “methodological struggle between universalism and historical particularism,” “global modernization,” and “postmodern trends,” forming the concepts of “anthropology represented by Giltz” and “philosophy of scientific practice” (44). Locality, relativity, and particularity are prominent features of local knowledge: “it is a knowledge system that is generated in a certain context (such as historical, regional, ethnic, racial, etc.) and is confirmed, understood, and protected in that context” (45); “it is not a set of established and proven propositions, but a set of activities or practical processes” (46). In other words, local knowledge is the cognitive ability formed in specific object-oriented practices, and this cognitive ability has certain situational and special characteristics.

During the process of constructing curriculum content, the inheritance of intangible cultural heritage martial arts in universities places more emphasis on its local knowledge characteristics. It is not only the externalization of its own attributes in university inheritance, but also the reconstruction of its own attributes in university inheritance. On the one hand, intangible cultural heritage martial arts have already formed a local knowledge system in their own construction before being practiced in universities. This system is based on the natural resources, material environment, and humanistic spirit of regional culture. It is an internal regulation that maintains its own cultural style to a certain degree of cultural constancy and persistence and is also a source of life that distinguishes itself from others. In this system, local cultural knowledge plays a role in the cultural construction inherited by universities, forming a curriculum system with local characteristics. As Professor Chen Zhenyong said, “Cultural reconstruction is the contemporary value reproduction of regional martial arts culture research” (47). As a form of local knowledge with regional cultural attributes, intangible cultural heritage martial arts play a role in reproducing contemporary values in the curriculum construction of university inheritance; this function is also essential to regulating cultural inheritance. The cultural inheritance of intangible cultural heritage martial arts in universities aims to transmit the accumulated cultural power to students, thus achieving intergenerational cultural continuity through the educational mechanism. On the other hand, the inheritance of intangible cultural heritage martial arts in universities is influenced by the new teaching environment. It is necessary to redefine curriculum construction and achieve innovative transformation in the inheritance of intangible cultural heritage martial arts in universities. However, this innovative transformation is based on its own characteristics.

Regarding the integration of intangible cultural heritage martial arts in universities, although it has entered universities from the private sector and the educational environment has changed, the introduction of intangible cultural heritage martial arts into universities is a cultural identity that supplements the existing school martial arts education. Whether it is the purpose, object, method, or content of inheritance that differs from traditional martial arts education, it is a culturally centered martial arts



inheritance. Although intangible cultural heritage martial arts has not changed, the focus of university inheritance has shifted from physical fitness to intellectual and emotional development. In other words, “culture” is the ultimate goal of intangible cultural heritage martial arts in universities. This is also why intangible cultural heritage martial arts highlight its local knowledge in the inheritance of universities. Local knowledge represents the deepest and most simple aspects of traditional culture. In this sense, curriculum construction in the inheritance of intangible cultural heritage martial arts in universities is also a reconstruction of local knowledge. Local knowledge is a concept of inheritance, and the specific implementation of this cultural concept requires intangible cultural heritage martial arts to highlight its core technical skills in university inheritance.

## 5.2 Highlighting the core craftsmanship of body techniques

Body technology is a concept suggested by French sociologist Moss, who believes that “the body is the first and most natural tool for humans, or rather the first and most natural technological object and means” (48). In this sense, the body serves as a technology that reflects the cultural concept of the body as a tool or instrument. From the Chinese perspective of the body, it is considered the foundation of human existence. As Zhang Zailin said, “If Western philosophy is based on consciousness, then ancient Chinese philosophy is based on the body” (49). Essentially, intangible cultural heritage martial arts is one of physical movement, but the body plays an important role. At the same time, physical exercise is influenced by cultural beliefs. The physical attributes of these martial arts determine the instability and heterogeneity of the techniques of different practitioners. On the one hand, this characteristic offers infinite possibilities for the reconstruction of intangible cultural heritage martial arts body techniques; on the other hand, it creates obstacles in maintaining the cultural style of boxing.

In universities, the aim of inheritance of intangible cultural heritage martial arts is to use body technology to convey traditional Chinese culture. However, due to the variability and individuality of body techniques, the inheritors must emphasize more on the core craftsmanship of its body techniques in the process of curriculum construction. Their main aim is to maintain the style of boxing and the characteristics of traditional culture, and limit the influence of body deformation. First, there is integrated creation through reorganizing the core skills of dozens of boxing equipment routines in this boxing genre, selecting representative technical movements that can represent the style of this boxing genre, and creating new representative routines to ensure the technical characteristics of the boxing genre. Second, there is transplantation for reference. This form of curriculum construction mainly occurs in universities that lack inheritors of intangible cultural heritage martial arts and where ordinary university teachers assume the role of inheritors. For them, they are not the inheritors of intangible cultural heritage martial arts, so they need’t undergo the stage of innovative

transformation. Instead, they directly use a nationally recognized intangible cultural heritage martial arts as the curriculum content. Third, there is direct transplantation, which is the curriculum construction of intangible cultural heritage martial arts in universities that does not integrate and create routines for college students. The mature and established routines in the school are used as course content, and selection is based mainly on students’ interests, needs, majors, and employment prospects. However, regardless of the way intangible cultural heritage martial arts are constructed in universities, they all have the same goal: to highlight the core skills of intangible cultural heritage martial arts; to distinguish them from the established martial arts content in university education; to highlight the value of their traditional culture; and to emphasize their cultural heritage.

## 5.3 Emphasizing the cultural tradition of physical skills

The cultural tradition is closely related to Chinese culture, Chinese traditional culture, and excellent Chinese traditional culture, and there is a certain inherent relationship between them. In Li Zonggui’s view, Chinese culture and traditional Chinese culture are different expressions of the same concept. Chinese culture is formed based on the national significance of Chinese traditional culture, and the two are consistent in connotation. Excellent traditional Chinese culture, a subset of Chinese culture, reflects the healthy spiritual direction of Chinese culture, inspires people to move forward, inspires national self-confidence and pride, has the function of national cultural identity, historical inheritance and stability, and still has strong vitality today (50). In this sense, the traditionality of culture is a mainline that connects Chinese culture to inherit both the past and the present in historical changes, and then connects the future. For those who are immersed in culture, their understanding of cultural tradition belongs to the subconscious level of cultural identity, and they only become aware when the cultural environment undergoes changes. As Liu Kuili said, the recognition of cultural traditions, just like water to fish and air to birds, is natural and indifferent. Only when a nation faces the impact of different cultures, or when a person is immersed in another cultural system, will they explore and experience the value of cultural traditions and generate a strong sense of identity (51). It can be inferred that the presentation of cultural tradition requires certain historical conditions and the cultural consciousness of the parties involved.

For the inheritance of intangible cultural heritage martial arts in universities, cultural tradition is a valuable cultural quality. In the course of historical changes, due to its consistent cultural style of traditional martial arts, it has become more imbued with the style of excellent traditional Chinese culture, which is also the value and significance of its entry into universities for inheritance. In other words, the inheritance of intangible cultural heritage martial arts in universities is based on highlighting the traditional nature of culture. Without it, the value of its inheritance would be lost. From a physical education perspective,

there are numerous and exquisite teaching projects in physical education in schools, and students have many opportunities to choose projects, including various compulsory, elective, and limited elective courses, as well as other martial arts projects. However, a common goal of these projects is to promote the physical and mental health of students. There are few projects that truly inherit culture, which is determined by the cultural attributes of the projects themselves in physical education in schools, differing from intangible cultural heritage martial arts. Its main purpose is not only to promote the physical and mental health of students, but more importantly, to teach traditional Chinese cultural values. Cultural inheritance is the main theme of its introduction into universities. This is also an important reason for inheritors of intangible cultural heritage martial arts to adhere to cultural tradition in curriculum construction. More importantly, the main aim is to construct a system curriculum cultural symbols. From this, it can be seen that highlighting the cultural tradition of intangible cultural heritage martial arts in university is the foundation, and it is also the fundamental basis for the long-term development of intangible cultural heritage martial arts in university. As Wang Gang and Qiu Pixiang stated, “Innovation without tradition is pale and without foundation; only by paying attention to tradition, learning from tradition, and applying tradition can tradition continue to flow” (52).

## 6 Conclusion

The aim of this study was to explore the process of integrating intangible cultural heritage martial arts into the modern school education system from an educational ethnography perspective. According to the nature of curriculum construction, the curriculum construction for the inheritance of intangible cultural heritage martial arts in universities can be divided into three categories. The first category is the curriculum construction mainly composed of teachers on campus. The inheritors of this type of curriculum construction are relatively complex and can be divided into inheritors with a teacher-teacher relationship with the public and in-service teachers in universities (including martial arts teachers and other physical education teachers). The former, due to their relationship with the public, has a relatively complete skill system for intangible cultural heritage martial arts; therefore, the curriculum of inheriting intangible cultural heritage martial arts in universities has been reorganized to form a curriculum with characteristics of university inheritance. The latter do not have a teacher-student relationship with inheritors of intangible cultural heritage martial arts in folk. The curriculum construction of inheriting intangible cultural heritage martial arts in universities adopts the method of directly transplanting intangible cultural heritage martial arts content into the normal curriculum system. Therefore, the curriculum construction belongs to direct transplantation rather than creative utilization. The second category is curriculum construction dominated by off-campus inheritors who mainly come from the public arena. They tend to focus more on local knowledge in curriculum construction and construct a curriculum system that

belongs to the local curriculum. Their main principle when selecting course content is to meet the professional needs of students and inherit excellent traditional Chinese culture. Curriculum construction is not about rebuilding the boxing system and integrating the inheritance content, but about selecting or intercepting boxing routines that are suitable for the characteristics of college students from existing boxing styles to enrich the course content. The third category of curriculum construction is centered around base construction, and the inheritors of this type of curriculum construction are the most complex among the three types of curriculum construction. The inheritors of curriculum construction include both external inheritors and internal inheritors, as well as in-service teachers in universities. Therefore, curriculum construction is the product of the three categories interacting. However, regardless of the type of curriculum construction in the inheritance of intangible cultural heritage martial arts in universities, the curriculum content exhibits local, core, and traditional characteristics to form a university curriculum system that is different from the folk inheritance system. These curricula can effectively compensate for the cultural deficiencies in modern school martial arts education and also play a role in continuing China's excellent traditional culture. Among them, locality is determined by the regional characteristics of intangible cultural heritage martial arts, and the core emphasizes the core skills of intangible cultural heritage martial arts, which are determined by the style of boxing. Tradition is the cultural value of intangible cultural heritage martial arts, which is determined by the historical genes of intangible cultural heritage martial arts.

## 7 Practical applications

Based on the above conclusions, this study further discusses how traditional Chinese martial arts can be integrated into the school education system. Chinese martial arts is a cultural symbol system formed on the basis of traditional Chinese culture, playing an important educational role in the historical process. Since modern times, Chinese martial arts have gradually embarked on a journey of modern school martial arts education under the influence of modern Western sports ideas. However, in this process, how to integrate traditional martial arts culture into the modern educational system has become an important research question, and a unified answer has not yet been formed. A study has pointed out that “martial arts education entering schools should be mandatory and not allowed to be chosen by students, because students lack recognition of the competition of national culture” (53). Although incorporating martial arts into the modern educational system through mandatory means can have a certain effect, this approach can only solve temporary problems and cannot break through the inherent vitality of martial arts education, which ignores the subjectivity of students. From the essence of education, the vitality of school martial arts education comes from the inherent quality of martial arts, which fundamentally implements the educational goal of putting people first. Through compulsory means, the student-centered teaching

purpose is ignored, which is not conducive to the integration of traditional martial arts culture into the modern curriculum system. Since the establishment of the People's Republic of China, Chinese martial arts has always been an important part of the school physical education curriculum, but it has never truly solved the difficulties in its education. It can be seen that simply using compulsory means cannot fundamentally solve the problem of integrating traditional martial arts culture into modern educational systems. When exploring the implementation path of protecting and inheriting traditional martial arts, Wang Gang and others believe that the folk inheritance methods of traditional martial arts should be combined with modern educational inheritance, the educational awareness of traditional martial arts should be strengthened, the originality in the inheritance process of boxing should be highlighted, and the cultivation of traditional martial arts elites should be placed on higher education, breaking through the inherent educational model (54). Another study also suggested that choosing boxing as content of the school martial arts education is a top strategy, because it has touching stories, a minimalist technical start, profound theories, and a systematic culture that runs through it (27). These studies emphasize the educational awareness, originality, technical simplification, profound theory, and important role of higher education in cultivating traditional martial arts talents but have not yet been proven in practice. This study provides further practical evidence for the integration of traditional martial arts into the school education system, and also verifies the feasibility and effectiveness of adhering to the traditional characteristics of boxing.

When discussing the ways in which traditional martial arts can be integrated into the modern school education system, Liu Wenwu puts the key to the construction of martial arts teachers. He advocates that the content of talent cultivation in sports colleges should shift from competitive martial arts to traditional martial arts, and that university martial arts teachers should delve into folk customs and improve teaching management departments (34). Some scholars also believe from the perspective of communication studies that the educational function of martial arts is different from other sports, as well as from Chinese language, history, and moral education. It is an organic unity of cultural education and physical education (55). Starting from the characteristics of traditional martial arts themselves, these views have profound insights. The feasibility of traditional martial arts is determined by the martial arts teachers, and the unique advantages of traditional martial arts in school education can also be leveraged. However, these views have not yet taken into account the spatial environment and field characteristics in which school martial arts education plays a role. In other words, the inheritance of intangible cultural heritage martial arts in universities should not transfer traditional martial arts skills and culture to universities but should go through technological transformation and innovation. The results of this study show that the inheritance of intangible cultural heritage martial arts in universities is a simplified, core, and traditional cultural inheritance. It is based on the skill reconstruction in the educational context of universities to embody the characteristics and cultural style of traditional martial arts rather than a simple

transplantation of traditional martial arts from the public to universities. In this sense, the core of how traditional martial arts are integrated into the modern school education system should not only focus on the role of inheritors of intangible cultural heritage martial arts, but also on cultivating innovative talents with condensed characteristics of intangible cultural heritage martial arts and high-level “coach type” talents who effectively convey the characteristics of intangible cultural heritage martial arts to relevant teachers. This is the current and future key to integrating traditional culture into the modern school education system. It is also a guarantee for establishing the continuity of Chinese national culture through school mechanisms.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Ethics statement

The research was approved by China West Normal University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

YC: Investigation, Project administration, Writing – original draft, Writing – review & editing. NG: Data curation, Investigation, Writing – original draft, Writing – review & editing.

## Funding

The authors declare financial support was received for the research, authorship, and/or publication of this article.

The article was supported by the China West Normal University Basic Research Project (Humanities and Social Science Projects):No.59. The Inheritance and Development of Ethnic Traditional Sports from the Perspective of Localization: A Case Study of Nanchong City.

## Acknowledgments

The authors thank everyone for their help in the process of fieldwork and the writing stage.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated

organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Yang JY, Wang JH. A discussion on how to protect the intangible cultural heritage of Wushu. *J Chengdu Sport Univ.* (2016) 42(2):56–61. doi: 10.15942/j.jcsu.2016.02.010
- Yin BC, Zhang F, Gong MF. Review of research on Wushu cultural inheritance from the perspective of social change and culture. *J Xi'an Phys Educ Univ.* (2017) 34(3):318–27. doi: 10.16063/j.cnki.issn1001-747x.2017.03.011
- Cui LQ. Research report on intangible cultural heritage of traditional sports, amusement and acrobatics in 2020. *China Intangible Cult Herit.* (2021) (3):65–83.
- Zhang XJ. Cultural construction and cultural attention in curriculum. *Educ Rev.* (2002) 6:11–4.
- Feng XX. Constructing kindergarten curriculum based on activity theory. *Stud Early Child Educ.* (1997) 4:22–6.
- Jing Y, Zhou ZH. Curriculum outlook from structuralism to constructivism & its revelation. *Theory Pract Educ.* (2006) 20:45–8.
- Xin T, Jiang Y, Wang YH. Curriculum system constitution based on students' key competencies. *J Beijing Norm Univ.* (2014) 1:5–11.
- Ge XY. Exploration of kindergarten mixed age education and its course. *Stud Early Child Educ.* (2012) 7:64–6. doi: 10.13861/j.cnki.sece.2012.07.014
- Hao DY. A constructive curriculum cultural view towards cultural criticism and generation. *Educ Res.* (2001) 6:61–5.
- Su D. The content and the curriculum construction of multi-cultural education in ethnic minority regions. *J Minzu Univ China.* (2008) 1:88–94. doi: 10.15970/j.cnki.1005-8575.2008.01.017
- Chen P. The basic idea and strategy of the curriculum construction of local culture. *Curr Teach Mater Method.* (2005) 7:39–42. doi: 10.19877/j.cnki.kcjcj.2005.07.008
- Sheng HX. Grand view concept and curriculum construction based on grand view concept. *Contemp Educ Sci.* (2015) 18:27–31.
- Song L, Zhang H. The core characteristics of the embodied curriculum and its narrative construction. *Curr Teach Mater Method.* (2019) 39(2):37–43. doi: 10.19877/j.cnki.kcjcj.2019.02.006
- Jiang DG, Hao DY. The cultural mission of construction mission in contemporary curriculum. *J High Educ.* (2001) 6:86–9.
- Liu XF, Chen L, Wang LN, Feng M. A study on construction of core literacy for information technology curriculum in wisdom age. *China Educ Technol.* (2018) 10:55–61.
- Guo ZM. Personal construction and subject amalgamation—new idea of American Teachers' education curriculum. *Theory Pract Educ.* (2004) 7:53–6.
- Jin YZ, Zhao Q, Chen BX, Guan YS. A study on the vitality of school Wushu—academic history narration from the perspective of school Wushu. *Sports Sci.* (2022) 43(4):62–7. doi: 10.13598/j.issn1004-4590.2022.04.008
- Shi L, Lu XH. An analysis of the relationship between Wushu education and physical expressive literacy cultivate. *Sports Sci.* (2024) 45(1):80–8. doi: 10.13598/j.issn1004-4590.2024.01.011
- Liu T, Zhang Y. Integration and development of national spirit cultivation and Wushu education in schools from the perspective of interaction ritual chains. *J Ethnology.* (2022) 13(5):108–13,142.
- Yang JY. Value orientation of Wushu education based on the goal of national rejuvenation: fostering the spirit of vigor and self-strengthening. *J Tianjin Univ Sport.* (2021) 36(3):293–9. doi: 10.13297/j.cnki.issn1005-0000.2021.03.007
- Jin YZ, Li WL, Li CR, Chen BX. Shendao logic of "Shi" in Chinese Wushu and the enlightenment of contemporary aesthetic education. *J Tianjin Univ Sport.* (2023) 38(4):455–61. doi: 10.13297/j.cnki.issn1005-0000.2023.04.013
- Jin YZ, Li L, Dong G. The essence meaning, value purport and practice of Chinese Wushu body aesthetic education. *J Xi'an Phys Educ Univ.* (2023) 40(1):98–104. doi: 10.16063/j.cnki.issn1001-747x.2023.01.011
- Wu XT, Ji CZ. Value intention, realistic constraints and implementation path of the "educating five domains simultaneously" in school martial arts for diversified education. *J Shandong Sport Univ.* (2024) 40(1):87–96. doi: 10.14104/j.cnki.1006-2076.2024.01.010
- Liu WW. Highlighting the attribute of combat and interest: two key points to break the predicament of Wushu education. *Sports Sci.* (2023) 44(4):76–85. doi: 10.13598/j.issn1004-4590.2023.04.008
- Zhang ML, Qiu L. The reform of the school Wushu curriculum: predicaments and outlets. *J Shandong Sport Univ.* (2019) 35(5):77–83. doi: 10.14104/j.cnki.1006-2076.20191119.001
- Zhao GS, Dai GB. Predicament and reform path selection of the national school Wushu education—written on the foundation of the Wushu league of the national school sports. *J Shanghai Univ Sport.* (2014) 38(1):84–8. doi: 10.16099/j.cnki.jsus.2014.01.016
- Wang G. Review on the history of school Wushu education and its contemporary development. *J Beijing Sport Univ.* (2016) 39(6):90–5, 101. doi: 10.19582/j.cnki.11-3785/g8.2016.06.014
- Tan XY. To construct a curriculum model in Wushu education from theories of sport education. *Sports Sci.* (2009) 30(2):82–6.
- Wu MD, Li Z, Zhang P, Jiang CY. Exploring the development of school based martial arts curriculum in primary and secondary schools under the background of "one school, one fist" education reform. *Sports Cult Guide.* (2017) 10:145–9.
- Research Group on the Reform and Development of School Martial Arts Education. Investigation on Wushu education in primary and middle schools in China. *China Sport Sci.* (2009) 29(3):82–9. doi: 10.16469/j.css.2009.03.014
- Yang XQ. Shaping the spirit and educating the student: research on the urgency and advantages of sports course ideological construction. *J Tianjin Univ Sport.* (2020) 35(1):13–6. doi: 10.13297/j.cnki.issn1005-0000.2020.01.003
- Xue X, Gao YQ. The return and orientation of school Wushu's education under the concept of "curriculum with thought and politics" in the new era. *J Nanjing Sports Institute.* (2019) 2(5):74–80, 2. doi: 10.15877/j.cnki.nsin.2019.05.011
- Yu DH, Zhang ML. On the reform and its cultural route of Wushu curriculum in universities and colleges. *J Shanghai Univ Sport.* (2012) 36(3):23–6. doi: 10.16099/j.cnki.jsus.2012.03.008
- Liu WW. Research on the necessity and ways of integrating traditional Wushu into China's school system. *J Beijing Sport Univ.* (2013) 36(1):97–101. doi: 10.19582/j.cnki.11-3785/g8.2013.01.019
- Wu D, Lv SJ. The study on the reform of the martial arts curriculum system in institution of higher education. *J Beijing Sport Univ.* (2013) 36(3):92–8, 105. doi: 10.19582/j.cnki.11-3785/g8.2013.03.017
- Lv SJ, Peng F. Reform and suggestion of school Wushu course. *J Beijing Sport Univ.* (1997) 4:54–8. doi: 10.19582/j.cnki.11-3785/g8.1997.04.012
- Sun XE. In-depth interview research: method and techniques. *J Xi'an Jiaotong Univ.* (2012) 32(3):101–6. doi: 10.15896/j.xjtusxb.2012.03.019
- Fossey E, Harvey C, Mcdermott F, Davidson L. Understanding and evaluating qualitative research. *Aust N Z J Psychiatry.* (2002) 6:717–32. doi: 10.1046/j.1440-1614.2002.01100.x
- Feng Z. *Educational Anthropology*. Nanjing: Jiangsu Education Press (2000).
- Yang JY. The developing road of Chinese Wushu in deep trouble—an academic interview with professor Qiu Pixiang. *Sports Sci.* (2018) 39(4):18–25. doi: 10.13598/j.issn1004-4590.2018.04.004
- Li SM. The operation and individual adaptation on cultural function of local teaching materials. *J Educ Sci Hunan Norm Univ.* (2009) 8(2):25–9.
- Zhong Q, Li Q. *New Advances in Educational Science*. Shaanxi: People's Education Press (1993).
- Cheng SR. The development of local curriculum in the view of the local knowledge. *Curr Teach Mater Method.* (2007) 9:3–8. doi: 10.19877/j.cnki.kcjcj.2007.09.001
- Wu T. On two kind of "local knowledge"—furthermore A review of viewpoints from Geertz and Rouse. *Stud Dialect Nat.* (2007) 11:87–94. doi: 10.19484/j.cnki.1000-8934.2007.11.024
- An FH. On the value of local knowledge. *Contemp Educ Cult.* (2010) 2(2):34–41. doi: 10.13749/j.cnki.cn62-1202/g4.2010.02.003
- Sheng XM. The construction of local knowledge. *Philos Res.* (2000) 12:36–44,76–77.
- Chen ZY. Regional Wushu culture studies: a perspective of anthropology. *J Chengdu Sport Univ.* (2016) 42(2):51–5, 109. doi: 10.15942/j.jcsu.2016.02.009
- (France) Mauss. *Five Lectures on Anthropology and Sociology* (Lin Z, Trans). Guilin: Guangxi Normal University Press (2008).

49. Zhang ZL. Ancient Chinese philosophy as “body philosophy”. *J Humanit.* (2005) 2:28–31. doi: 10.15895/j.cnki.rwzz.2005.02.006
50. Li ZG. On the connotation of excellent traditional Chinese culture. *Acad Res.* (2013) 11:35–9.
51. Liu KL. Theoretical reflection on the protection of intangible cultural heritage. *Folk Cult Forum.* (2004) 4:51–4. doi: 10.16814/j.cnki.1008-7214.2004.04.013
52. Wang G, Qiu PX. Pondering on the development of national sport under globalization. *Sports Sci.* (2006) 4:26–9.
53. Guo YC. Inheriting characteristics, contemporary value and developmental strategy of Chinese folk Wushu. *J Shanghai Univ Sport.* (2007) 2:40–4. doi: 10.16099/j.cnki.jsus.2007.02.009
54. Wang G, Zhu JB. Research on implementation route of traditional Wushu protection and inheritance. *J Cap Univ Phys Educ Sports.* (2011) 23(4):292–5, 312. doi: 10.14036/j.cnki.cn11-4513.2011.04.005
55. Guo YC. Awareness of Wushu culture communication: from going out of the tradition to the discovery of tradition. *China Sport Sci Technol.* (2007) 1:25–8. doi: 10.16470/j.csst.2007.01.006





## OPEN ACCESS

## EDITED BY

Lazar Toskić,  
University of Pristina, Serbia

## REVIEWED BY

Darjan Smajla,  
University of Primorska, Slovenia  
Nemanja Lakicevic,  
University of Palermo, Italy  
Bayram Ceylan,  
Kastamonu University, Türkiye

## \*CORRESPONDENCE

Pavel Ruzbarsky  
✉ pavel.ruzbarsky@unipo.sk

RECEIVED 15 May 2024

ACCEPTED 25 June 2024

PUBLISHED 12 July 2024

## CITATION

Nema K, Ruzbarsky P, Rydzik Ł and Peric T  
(2024) Relationship of selected conditioning  
parameters and sport performance indicators  
in karate.  
Front. Sports Act. Living 6:1433117.  
doi: 10.3389/fspor.2024.1433117

## COPYRIGHT

© 2024 Nema, Ruzbarsky, Rydzik and Peric.  
This is an open-access article distributed  
under the terms of the [Creative Commons  
Attribution License \(CC BY\)](#). The use,  
distribution or reproduction in other forums is  
permitted, provided the original author(s) and  
the copyright owner(s) are credited and that  
the original publication in this journal is cited,  
in accordance with accepted academic  
practice. No use, distribution or reproduction  
is permitted which does not comply with  
these terms.

# Relationship of selected conditioning parameters and sport performance indicators in karate

Kristina Nema<sup>1</sup>, Pavel Ruzbarsky<sup>2\*</sup>, Łukasz Rydzik<sup>3</sup> and  
Tomas Peric<sup>4</sup>

<sup>1</sup>Department of Educology of Sports, Faculty of Sport, University of Presov, Presov, Slovakia,

<sup>2</sup>Department of Sports Kinantropology, Faculty of Sport, University of Presov, Presov, Slovakia, <sup>3</sup>Institute of Sports Sciences, University of Physical Education in Krakow, Krakow, Poland, <sup>4</sup>Department of Sports Educology and Humanities, Faculty of Sport, University of Presov, Presov, Slovakia

**Introduction:** The variables of aerobic performance and aerobic capacity are of significant importance in maintaining intensity during a fight and also contribute to faster recovery between rounds in sports fighting in karate. Anaerobic performance is crucial for the execution of the techniques during high-intensity offensive or defensive actions that determine the outcome of a fight. The objective of this study was to assess the relationship between selected performance indicators of aerobic and anaerobic capacity to sports performance in karate.

**Methods:** The study included six male karate athletes (age  $28 \pm 3$  years, body mass 85.10 kg; height 185.5 cm), medalists from European and World championship, events in senior categories. The selection criteria included training experience and sports level. The Karate specific aerobic test (KSAT) was use in conjunction with heart rate monitoring and changes in blood lactate levels to diagnose special aerobic endurance parameters. To determine the level of anaerobic performance the Wingate test were choosed. Technical and tactical indicators (efficiency, effectiveness and activeness of the attack) were used to assess the sports skill level during competition.

**Results:** Based on the Spearman correlation coefficient results demonstrated statistically significant differences ( $r_s = -0.81$ ) with large effect size index between efficiency of the attack and average heart rate achieved in the test KSAT. Additionally statistically significant differences ( $r_s = 0.81$ ) with large effect size were demonstrated between the fatigue index and efficiency of the attack Furthermore, the selected indicators of special aerobic endurance parameters and anaerobic performance demonstrated a high degree of predictive validity in relation to the efficiency ( $r_p = 0.960$ ) and activity ( $r_p = 0.927$ ) of attacks.

**Conclusion:** The high level of predictive validity confirmed the importance of a high level of anaerobic conditions for performance in karate. The low values of the average heart rate in relation to the efficiency of the attack confirm the high performance level of karate athletes in relation to special aerobic performance parameters. It was found that the effectiveness of the attack had no relation to the monitored parameters.

## KEYWORDS

combat sports, aerobic performance, anaerobic performance, technical indicators, tactical indicators

# 1 Introduction

In the contemporary era, karate is widely regarded as a combat sport, wherein the traditional tenets of the martial art are blended with the tenets of a modern fighting sport. Research into this sport has demonstrated that fighting in karate is typified by a high-intensity acyclic activity comprising brief, intense actions interspersed with periods of low-intensity rest (1). The effort expended in a karate match is not uniform; rather, it can vary in flow, rhythm and pace depending on whether the referee has interrupted it or not. Due to the intermittent nature of kumite, the total energy cost in a fight is approximately paid by the aerobic component (70%), with the utilisation of alactic energy stores (20%) and lactic acid production (10%) (2). Similar findings were also recorded in research by Beneke et al. (3), which demonstrated that from a physiological perspective, aerobic metabolism is the primary source of energy during the sport of kumite. However anaerobic supplementation and high-energy phosphates also contribute to this process. Nevertheless, it is possible that the aforementioned reactions may differ between official and simulated matches. A number of studies have indicated that the overall metabolic profile is predominantly aerobic, although anaerobic processes exert a critical influence (2–4). Consequently, it has been proposed that in order to achieve a high level of competitive performance, karate athletes must develop both anaerobic and aerobic fitness (2).

It is important to consider both aerobic capacity and aerobic power when evaluating an athlete's fitness. Aerobic power allows an athlete to maintain a high intensity for longer periods during a match, while aerobic capacity contributes to faster recovery between consecutive matches. The traditional approach to evaluating the aerobic fitness of karate athletes has involved the use of laboratory treadmill and cycle-ergometer tests to determine maximal oxygen uptake. Although laboratory tests are accurate, their lack of sport specificity is a significant criticism of these assessment methods (5). To assess specific aerobic performance in karate, the Karate-specific aerobic test (KSAT) was developed (6), which, according to Chaabene et al. (7), can effectively distinguish between different levels of karate practitioners, for example, national vs. regional level. The study by Tabben et al. (5) demonstrated that the KSAT was a reliable assessment tool, with oxygen consumption values recorded during the KSAT exhibiting a strong correlation with those obtained from the cycle ergometer test ( $r = 0.81$ ;  $R^2 = 65\%$ ). Furthermore, the time to exhaustion during the KSAT displayed a very large correlation with  $VO_{2max}$  from laboratory tests ( $R^2 = 65\%$ ).

Anaerobic performance is crucial for the execution of techniques during high-intensity attacking or defensive actions that are responsible for scores during a match. Conversely, anaerobic capacity is considered less important for karatekas because the duration of high-intensity actions is relatively brief. Given the absence of karate-specific anaerobic tests, the majority of research has employed the Wingate test to assess anaerobic performance. This approach has been adopted by numerous studies (2, 8–11). According to Zemková (8), maximum power at

the beginning of the load refers to the ability to mobilise energy in a very short period of time, which expresses the level of maximum anaerobic power. This capacity to generate maximum power in brief time intervals is employed primarily in offensive and defensive actions. The average performance, defined as the total work done in 30 s, is indicative of the capacity to resist fatigue during an intense short-term load, such as a karate match. It is a measure of maximum anaerobic capacity.

To assess anaerobic endurance, the fatigue index is employed as an additional parameter, representing the decline in performance expressed as a percentage from the initial to the final phase of the load (5, 8, 12, 13). An alternative approach is to quantify the load intensity through the use of appropriate indicators of the body's response to loads. The most commonly employed indicator is the level of blood lactate in the blood, which is highly responsive to the load, during which the organism is compelled to meet a portion of its energy needs anaerobically.

The objective of this study is to examine the relationship between selected aerobic and anaerobic parameters and sports performance indicators in karate. The study's objective was to formulate a research question. This question was: What is the relationship between the levels of aerobic and anaerobic parameters (assessed through KSAT and WAnT) and the levels of specific performance indicators in karate?

## 1.1 Hypothesis

There is a significant relationship between selected aerobic and anaerobic parameters and sports performance indicators in karate. Specifically, lower average heart rate values and higher fatigue index values are associated with higher attack efficiency in karate.

# 2 Material and methods

## 2.1 Participants

The study included 6 male karate athletes from Poland, with an average age of  $28 \pm 3$  years. According to the results of the previous competition season, the karate athletes were included in the senior categories at the international level. They had fought an average of 15 fights per year in national and international tournaments and their training experience depending on their age was an average of  $9 \pm 1$  years. They were also medalists in European and World Championship. The weekly training load of the karate athletes was  $11 \pm 1$  h of training load. Inclusion criteria for the study were: sport discipline kumite, at least 5 years training experience and the sport level as assessed by authors' observation and coach's opinion, active competitor, uninterrupted training process for at least 6 months before inclusion in the study, no musculoskeletal injuries, gender, success in international competitions. Exclusion criteria were: injuries, gender, a training experience of less than 5 years, no competition results. The anthropometric characteristics of the karate athletes presented

were: body mass  $85 \pm 10$  kg, height  $185.5 \pm 6.50$ , body mass index  $24.95 \pm 0.95$  kg.m<sup>-2</sup>, body fat percentage  $17.2 \pm 3.35\%$  and free fat mass index  $70.00 \pm 3.30$  kg. Body composition was assessed using a Tanita BC-601 whole-body bioimpedance analyzer.

## 2.2 Diagnostics of aerobic and anaerobic parameters

To diagnose the level of aerobic parameters, was used a specific test by Nunan (6)- the Karate specific aerobic test (KSAT). The test consists of a combination of the most frequently used punches and kicks in karate (direct punch with the front hand—kizami tsuki, arc kick with the back leg—mawasi geri, direct punch with the back hand gyaku-tsuki, arc kick with the back leg—kiza mawasi geri), which the subject has to perform repeatedly within 7 s. This test is based on the principle of the beep test, where the time to perform the combination is not changed, but the length of the pause is changed, i.e., it is shortened. Time to exhaustion was used as the performance parameter in the KSAT test. The validity and reliability of the test have been verified in several studies (5, 7, 14).

Maximum and average heart rate recorded using Polar Team Pro (Polar Electro Inc., New York, USA) were chosen as an auxiliary indicators to monitor the intensity of the load during the KSAT.

The internal response of the body karate athlete's body to the completed exercise was assessed by monitoring changes in blood lactate (La) levels. Biochemical analysis of blood samples was performed using a Biosen C-line Clinic device (EKF Diagnostic GmbH., Cardiff, UK). Absolute changes and percentage decreases at specified time intervals were evaluated. Lactate clearance rate was determined as the difference between the subjects' blood lactate concentration at 5 and 15 min of recovery.

The Wingate test using the Cyclus 2 bicycle ergometer (RBM elektornik- automation GmbH., Leipzig, Germany) was chosen for the diagnosis of anaerobic parameters. It is a test that is most commonly used to assess the anaerobic capabilities of karate athletes (2, 8, 9). The performance parameters considered in the Wingate test were peak power, average power, anaerobic power, anaerobic capacity, average power and the fatigue index, which expresses the decrease in power during the test (IU). The mechanical resistance was set at 7.5% of the subject's body weight, based on the literature (15, 16). The test was performed according to the protocol described by the authors InBar O., Bar Or O., Skinner J. S (17).

Diagnosis of the selected tests was carried out over two days during one week, with a two-day break in between. On the first day, the karate athletes completed the Wingate test and body composition measurement. On the second day, the karate athletes completed the Karate specific aerobic test. Both tests were performed at the same time of the day, under the same conditions and constant room temperature (21°C). Prior to the tests, they were warned not to use any prohibited substances aids or medications, not to eat heavy meals for 12 h before the test,

and not to perform any physically demanding activities. They were also warned to take a day off before the test and to get enough sleep.

## 2.3 Measuring the indicators of technical and tactical training

In order to determine the level of athletic skill during the competition, the fights were analysed and appropriate calculations were made. Three fights of each karate athlete were analysed. The fights were supervised by two experts with karate coaching qualifications. The researchers recorded the data on special spreadsheets. The results were summarised, and the average of two records was taken. The analysis of each round was based on a digital recording of the fight. The indicators of technical and tactical training were then determined using the following formulas (18–21).

Efficiency of the attack ( $S_a$ )

$$S_a = \frac{n}{N}$$

N- Number of bouts.

n- Number of attacks awarded 1 pt.

Effectiveness of the attack ( $E_a$ )

$$E_a = \frac{\text{number of efective attacks}}{\text{number of all attacks}} \times 100$$

\* An effective attack is a technical action awarded a point.

\* Number of all attacks is the number of all offensive actions.

Activeness of the attack ( $A_a$ )

$$A_a = \frac{\text{number of all registered offensive actions of a karate athletes}}{\text{number of bouts fought by a karate athletes}}$$

## 2.4 Bioethical committee

The study was conducted according to the tenets of the Declaration of Helsinki (22). Written informed consent was obtained as a prerequisite for participation in the project. All subjects gave informed consent for invasive capillary blood sampling. The study was approved by the Bioethics Committee at the Regional Medical Chamber (No.287/KBL/OIL/2020).

## 2.5 Statistical analysis

Statistical analysis of the data was performed using Statistica 13.5 (Tibco Software Inc., California, USA). Statistical analysis was performed using non-parametric tests due to the small

number of research samples. The normality of the distribution was checked using Shapiro-Wilk test, which proved the normality of the studied variables. Spearman's correlation coefficient ( $r_s$ ) was used to determine the relationship between selected aerobic and anaerobic parameters and sports performance, with the level of statistical significance set at  $p < 0.05$ . The evaluation of ES index  $r$  was interpreted as  $0.10 \leq r < 0.29$ —small effect,  $r = 0.30 \leq r < 0.49$ —medium effect,  $r \geq 0.50$ —large effect based on Cohen (23).

The determination of the validity of the prediction of the efficiency and activeness of the attacks was based on exploration using the correlation coefficient. The calculation of the predictive validity was based on a regression analysis, where three

indicators (average heart rate, anaerobic power and fatigue index) were included as independent variables and the efficiency of the attack and the activeness of the attack were used as dependent variables.

### 3 Results

The results of indicators of specific aerobic endurance parameters together with indicators of anaerobic power parameters are presented in Table 1. The results of the efficiency, effectiveness and activeness of the attack are also shown in Table 1.

Based on the results of the Spearman correlation coefficient, statistically significant differences were found between efficiency of the attack and fatigue index ( $p = 0.05$ ). The effect size was evaluated as large ( $-0.81$ ). It is also possible to observe the occurrence of dependence between efficiency of the attack and average heart rate obtained in the KSAT test. This correlation was statistically significant at  $p < 0.05$ . The effect size was considered to be large ( $0.81$ ). Based on the determination of the critical value, the other correlations were not statistically insignificant (Table 2).

To estimate the importance of each variable, three indicators with the highest correlation value (average heart rate, anaerobic power and fatigue index) were selected, which were entered into the regression equation (Table 3). The results of the regression statistic was for the efficiency of the attack: multiplied  $R = 0.96$ , reliability value  $R = 0.92$ . And for the activeness of the attack was multiplied  $R = 0.93$ , reliability value  $R = 0.86$ . The predictive validity of these indicators was calculated for the selected performance parameters.

The determination of the predictive validity of the efficiency and activeness of attacks was calculated using a correlation based on the predicted values from the regression equation and the results obtained in the given variable. The predictive validity was 0.96 for the efficiency of the attack

TABLE 1 Monitored parameters.

Variables		Karate athletes ( $n = 6$ )	
		Med	QD
Indicators of special aerobic endurance parameters	KSAT [s]	904.00	28.50
	Maximal HR [bpm]	196.00	8.00
	Average HR [bpm]	177.00	6.50
	LCR [mmol/L]	3.94	0.23
	Lactate after 3 min. [mmol/L]	12.07	2.14
Indicators of anaerobic power parameters	Peak power [W]	951.15	49.60
	Average power [W]	733.20	35.60
	Anaerobic power [ $\text{W} \cdot \text{kg}^{-1}$ ]	10.60	0.15
	Anaerobic capacity [ $\text{W} \cdot \text{kg}^{-1}$ ]	8.60	0.15
	Fatigue index [%]	44.88	9.88
	Average force [N]	369.50	30.00
Indicators of technical and tactical training	Efficiency of the attack	8.00	1.25
	Effectiveness of the attack	17.74	2.08
	Activeness of the attack	47.75	11.25

KSAT, karate specific aerobic test; Maximal HR, maximal heart rate; Average HR, average heart rate; LCR, Lactate clearance rate; QD, quartile deviation; Me—median.

TABLE 2 Relationship between indicators of technical and tactical training and the results of fitness test.

Karate athletes		Indicators of technical and tactical training					
		Efficiency of the attack		Effectiveness of the attack		Activeness of the attack	
		$p$	$r$	$p$	$r$	$p$	$r$
Indicators of special aerobic endurance parameters	KSAT [s]	0.96	0.03	0.21	0.60	0.47	-0.37
	Maximum HR [bpm]	0.26	0.54	0.35	0.46	0.91	0.06
	Average HR [bpm]	<b>0.05*</b>	<b>-0.81<sup>b</sup></b>	0.79	0.14	0.16	-0.66
	LCR [mmol/L]	0.29	0.52	0.96	0.03	0.54	0.31
Indicators of anaerobic power parameters	Peak power [W]	0.26	0.55	0.87	0.09	0.79	0.14
	Average power [W]	0.70	-0.20	0.70	0.20	0.54	-0.31
	Anaerobic power [ $\text{W} \cdot \text{kg}^{-1}$ ]	0.20	0.60	0.46	-0.38	0.06	0.78
	Anaerobic capacity [ $\text{W} \cdot \text{kg}^{-1}$ ]	0.39	-0.43	0.65	0.23	0.57	-0.29
	Fatigue index [%]	<b>0.05*</b>	<b>0.81<sup>b</sup></b>	0.47	-0.31	0.11	0.71
	Average force [N]	0.83	-0.12	0.87	0.09	0.54	-0.31

KSAT, karate specific aerobic test; Maximal HR, maximal heart rate; Average HR, average heart rate; LCR, lactate clearance rate;  $r$  = Spearman's correlation coefficient and effect size (0.1—small; 0.3—medium; 0.5<sup>b</sup>—large);  $p$  = statistical significance \*— $p < 0.05$ . Bold indicates values that are statistically significant.

TABLE 3 Regression statistic.

	Efficiency of the attack	Activeness of the attack
Constant	−4.30	−278.37
Average heart rate	−0.10	0.39
Anaerobic power	2.67	18.04
Fatigue index	0.10	4.23

and 0.93 for the activeness of the attack. It turned out that the effectiveness of the attack was no related to the monitored parameters.

## 4 Discussion

The primary findings of the research indicate statistically significant differences between the efficiency of the attack and the fatigue index, as well as between the efficiency of the attack and the average heart rate achieved in the KSAT test. The high level of predictive validity confirmed the importance of maintaining a high level of anaerobic conditions for optimal performance in karate.

In the sport fight- kumite, as in other combat sports, the primary scoring criterion is the intensive use of punches and kicks (24). Therefore the technical and tactical performances during kumite depend on physical qualities (25), such as the maximum speed, explosive power and special endurance (9, 26–28). The results of the special aerobic performance parameters, expressed as time to exhaustion in the KSAT test, reached a median of 904 s. This can be interpreted based on the similarity of the research samples as a high level of special endurance, which is comparable to the results of other authors (26, 29). In the study by Silva et al. (29), seven karate athletes with a technical level of 1 Dan and above achieved a mean time of  $438.43 \pm 178.04$  s in the test. by Chaabene et al. (26) monitored the performance of 43 karate athletes with a technical level of 1 Dan and above, categorised according to their performance levels. The karate athletes in the study were of a similar age to the general population, with an average age of  $24.1 \pm 4.7$  years and with a sports age of  $9 \pm 5.2$  years. They trained four times a week for 2 h and achieved a mean time of  $841 \pm 134$  s. A second group of 19 karate athletes, aged  $25.6 \pm 3.3$  years and with a sports age of  $7 \pm 4.4$  years achieved  $871 \pm 150$  s in the test and  $881 \pm 158$  s. They performed the test twice, with a weekly interval.

The average and maximum heart rate values observed in our study were comparable to those observed during simulated and official fights at the national championship (26), where high-performance karate athletes achieved maximum heart rate values of  $193 \pm 8$  bpm and  $192 \pm 9$  bpm for official and simulated fights. The average heart rate was  $177 \pm 13.43$  bpm (91.70%  $SF_{max}$ ) for simulated fights and  $175 \pm 11$  bpm (91.14%  $SF_{max}$ ) for official fights. These findings indicate that the KSAT is an appropriate instrument for assessing the level of special endurance in karate athletes. Similarly, the results of the maximum heart rate with a

value of  $SF_{max} = 196 \pm 11$  bmp were also found in the research by Tabben et al. (5), when 17 karate athletes at an international level performed the KSAT test. Hausen et al. (30), in their research to assess the cardiorespiratory fitness of national level karate practitioners, used a different test, namely the Graded Karate Test, but it turned out that the performance of karate practitioners in this test was similar to the performance of karate practitioners in this research. Additionally, it was demonstrated that there were statistically significant differences between the efficiency of the attack and the average heart rate achieved in the KSAT test. The observed differences were statistically significant at the 0.05 level. The low values of the average heart rate in relation to the efficiency of the attack, indicate that karate athletes exhibit a high level of aerobic endurance. This was also corroborated by the high degree of predictive validity, efficiency, and activeness of the attack. It is possible that certain tendencies may indicate a higher correlation coefficient between maximum heart rate and technical tactical indicators. However, this was not statistically significant due to the limited size of the research sample.

A comparison of our findings with those of other combat sports reveals that the maximum heart rate values observed in kickboxing (31, 32) and Thai boxing (33, 34) are higher. As indicated by Slimani et al. (35) this may be attributed to the higher technical-tactical and energy demands inherent to karate compared to the aforementioned combat sports.

Following the completion of the KSAT test, the maximum blood lactate concentrations were recorded in the third minute following the conclusion of the test. The findings were consistent with those of Janssen (36) and Shepard (37), who state that after high-intensity exercise, blood lactate levels reach their highest values between 3 and 5 min. The observed correlation between the median of the lactate clearance rate recorded after the KSAT test and technical and tactical indicators suggests that karate who demonstrate superior recovery capabilities may be more adept at executing scored and non-scored attacks during competition. In comparison to the findings of (9), which monitored the concentration of lactate in the blood after 3 min from the end of the KSAT test with karate athletes of the international level, our karate athletes demonstrated a significantly higher concentration of lactate in the blood. In the study by Chaabene (9), the lactate concentration was found to be approximately  $6.23 \pm 1.03$  mmol/L. Similar values as Chaabene (9) were also recorded in other research studies. Beneke et al. (3) reported that the blood lactate concentration of karate athletes following a competitive karate fight was  $5.9 \pm 1.6$  mmol/L. Significantly lower results were observed during a simulated karate fight, with lactate concentrations of  $3.4 \pm 1$  mmol/L (4). The changes in blood lactate levels that occur after exercise are a highly dynamic variable. It is important to consider the possibility of intra-individual variability within the sampling methodology when determining the optimal sampling after loading. From a methodological standpoint, the disparate outcomes observed in our research may be attributed to the site of blood collection (fingertip). In this context, it was demonstrated that samples collected from the earlobe, as previously observed by Beneke



et al. (3), Lide et al. (4), Chaabane (9), exhibited lower blood lactate values than fingertip samples (38). Consequently, given that the blood samples in our research were obtained from the fingertips, it is possible that the lactate concentration determined following KSAT during our research may have been overestimated. The GKT yielded higher blood lactate concentration responses ( $\sim 14.6 \text{ mmol/L}^{-1}$ ) (30) compared to the Karate-specific test, a difference that may be explained by the nature of the movements performed in the different protocols or by the sample of training profiles. In the previous proposals, the athletes provided an active displacement between the strikes, whereas the KSAT increased the strike frequency.

The results of the predictive validity of efficiency and activeness of the attack, which monitor the number of scored and non-scored techniques in relation to individual rounds, indicate the importance of anaerobic performance in offensive and defensive actions responsible for scoring during the fight. A comparison of the anaerobic performance achieved in the Wingate test with other research (2, 10, 39), revealed that our karate athletes achieved significantly better results than those observed by Alp and Gorur (39), where the karate athletes under observation achieved values of  $6.97 \pm 1.54 \text{ W/kg}$ . Conversely, comparable results were observed in the other studies (40, 41). In the study of Ravier et al. (10) where national-level karate athletes demonstrated a mean power output of  $10.9 \pm 1.5 \text{ W/kg}$ . Concurrently, these authors also observed karate athletes of an international level with a maximum one-time power of  $12.5 \pm 1.3 \text{ W/kg}$ , while they noted significant differences between the two groups. These results, as reported by Chaabane et al. (26) appear to support the hypothesis that kumite performance is more dependent on anaerobic power than on anaerobic capacity itself. According to Chaabane (9), the aforementioned findings have significant practical implications, particularly when differentiating between karate athletes at varying competitive levels.

The indicative tendency between the median of anaerobic capacity in relation to the efficiency and activeness of the attack could be indicative of the nature of the karate for which the karate athletes are trained and which is characterised by a short duration of high-intensity offensive or defensive actions (3, 9). A comparison of the results of the anaerobic capacity in the Wingate test, similar to the anaerobic performance, revealed that the karate athletes in this study exhibited superior results compared to those of karate athletes from other studies who competed in the sport of kumite. Significantly lower values of average power per kilogram of body weight ( $5.12 \pm 0.99 \text{ watt/kg}$ ) were recorded for karate athletes in the research of Alp and Gorur (39). This result was comparable to that observed by Sanchez-Puccini et al. (42), where 19 karate athletes of international level also recorded lower values of anaerobic capacity ( $4.8 \pm 0.9 \text{ watt/kg}$ ). Doria et al. (2) recorded similar results of  $7.9 \pm 0.6 \text{ watt/kg}$  in three karate athletes of international level (medalists from the World and European Championships) with an average age of  $24 \pm 4.6$  years. Similar results of  $8.75 \pm 0.15 \text{ watt/kg}$  were found in the study of Nema and Ruzbarsky (40).

A comparison of the values of the maximum and average performance related to the body weight of the karate athletes in our research group with those of fighters in similar combat

sports, such as taekwondo (39, 43), Judo (44), MMA (45) or kickboxing (46), reveals karate athletes achieved similar results. The anaerobic power of taekwondo athletes was found to be  $7.3 \pm 0.68 \text{ watt/kg}$  (43),  $9.26 \pm 2.4 \text{ watt/kg}$  (39), that of MMA athletes ranged from 9.8 to  $10.4 \text{ watt/kg}$  (45) and that of kickboxers was  $10.5 \text{ watt/kg}$  (46),  $11.4 \pm \text{watt/kg}$  (47). The anaerobic capacity of taekwondo athletes was found to be  $5.12 \pm 0.99 \text{ watt/kg}$  (39), while that of MMA athletes was between 7.5 and  $7.9 \text{ watt/kg}$  (45). Finally, the anaerobic capacity of kickboxers was found to be  $7.82 \pm 0.57 \text{ watt/kg}$  (46).

The median value of the fatigue index, which is one of the parameters of anaerobic performance was 44.88%. These values correspond with the range of values for the decrease in performance observed in strength sports athletes at a high level of training, with a decrease of between 44.6% and 53.5% (48). Statistically significant differences were observed between the fatigue index and the efficiency of the attack. This may be attributed to the intermittent nature of kumite, where aerobic metabolism (70%) is the primary source of energy, followed by anaerobic lactate coverage (20%) and anaerobic lactate coverage (10%) (2). To facilitate comparison with other research, Sanchez-Puccini et al. (42) and Doria et al. (2) achieved better results, namely  $40.8 \pm 4.2$  (10) and  $34.1 \pm 14.1$  (40), where the karate athletes were aged between 27 and 35 years old and had participated in the highest international competitions for a minimum of 3 years.

A positive finding was the high level of predictive validity, confirming the importance of a high level of anaerobic prerequisites for performance in karate. Karate can be characterised as a sport with high-intensity intermittent sport. This finding is also based on the findings of other authors (2, 9). This has implications for training planning and the determination of the loading strategy.

## 4.1 Limitations of the study

The main shortcoming of our research is the small research sample of male karate athletes, which limits the generalisability of the findings. However it should be noted that this sample consisted of elite karate athletes, with medals from the European and World Championships. The statistical analysis of technical and tactical indicators evaluated the number of scored and non-scored techniques during the entire fight, we did not verify them during individual rounds of the fight. The technical tactical indicators were calculated on the basis of official fights at competitions, which did not allow us to monitor the heart rate during the fight and the concentration of lactate in the blood after the fight. We also did not compare the values of the technical and tactical indicators with other results, as we were the first to use these indicators for evaluation in karate.

## 5 Conclusions

The primary goal of karate training is to ensure the development of those skills that limit sport performance. Our

research assessed the relationship between selected aerobic and anaerobic performance indicators and performance in karate. The results showed statistically significant differences with a large effect size index between the efficiency of the attack and the average heart rate achieved in the KSAT test. The low values of average heart rate in relation to the efficiency of the attack confirm the high level of performance of karate athletes in terms of aerobic endurance. This was also confirmed by the high level of predictive validity of efficiency and activeness of the attack. The results also showed statistically significant differences with large effect size between fatigue index and efficiency of the attack. This can confirm the importance of anaerobic performance during offensive and defensive actions responsible for the scoring during the fight, based on the results of predictive validity efficiency and activeness of the attack, which monitor the number of scored and non-scored techniques in relation to individual rounds. It turned out that the effectiveness of the attack had no relation to the monitored parameters.

## 5.1 Practical implications

In order to be able to design a specific training programme aimed at the development of aerobic and anaerobic metabolism, it is necessary to point out the methods that are usually used to quantify the training load. The present study may indicate a modification of the training process in karate through the development of anaerobic prerequisites, which may affect the improvement of technical-tactical actions in the fight. However, due to the small research group, it would be advisable to carry out more extensive research with a larger number of male and female karate athletes.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by Bioethics Committee at the Regional Medical Chamber (No.287/KBL/OIL/2020). The studies were conducted in accordance with the local legislation and institutional requirements. The

participants provided their written informed consent to participate in this study.

## Author contributions

KN: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. PR: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. LR: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. TP: Conceptualization, Data curation, Formal Analysis, Methodology, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article.

The research was funded by Grant Agency for Doctoral Students and Young Researchers of the University of Presov: GaPU12/2022.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

1. Chaabene H, Negra Y, Bouguezzi R, Capranica L, Franchini E, Prieske O, et al. Tests for the assessment of sport-specific performance in Olympic combat sports: a systematic review with practical recommendations. *Front Physiol.* (2018) 9:386. doi: 10.3389/fphys.2018.00386
2. Doria C, Veicsteinas A, Limonta E, Maggioni MA, Aschieri P, Eusebi F, et al. Energetics of karate (kata and kumite techniques) in top-level athletes. *Eur J Appl Physiol.* (2009) 107(5):603–10. doi: 10.1007/s00421-009-1154-y
3. Beneke R, Beyer T, Jachner C, Erasmus J, Hütler M. Energetics of karate kumite. *Eur J Appl Physiol.* (2004) 92(4–5):518–23. doi: 10.1007/s00421-004-1073-x
4. Iide K, Imamura H, Yoshimura Y, Yamashita A, Miyahara K, Miyamoto N, et al. Physiological responses of simulated karate sparring matches in young men and boys. *J Strength Cond Res.* (2008) 22(3):839–44. doi: 10.1519/JSC.0b013e31816a5af6
5. Tabben M, Coquart J, Chaabène H, Franchini E, Chamari K, Tourny C. Validity and reliability of new karate-specific aerobic test for karatekas. *Int J Sports Physiol Perform.* (2014) 9(6):953–8. doi: 10.1123/ijspp.2013-0465
6. Nunan D. Development of a sports specific aerobic capacity test for karate—a pilot study. *J Sports Sci Med.* (2006) 5:47–53.

7. Chaabène H, Hachana Y, Franchini E, Mkaouer B, Montassar M, Chamari K. Reliability and construct validity of the karate-specific aerobic test. *J Strength Cond Res.* (2012) 26(12):3454–60. doi: 10.1519/JSC.0b013e31824eddda
8. Zemková E. Diagnostika trébovanosti karatistov (diagnostics of training adaptation in karate athletes). In: *Prínos úpolových Aktivít na Rozvoj Osobnosti Človeka (the contribution of combat activities to the development of a human personality)*. Bratislava, UK: Bratislava a NŠC (2008). p. 2–6. ISBN: 978-80-89197-92-7
9. Chaabene H. *Karate Kumite: How to Optimize Performance*. Foster City, CAOMICS group Ebook (2015).
10. Ravier G, Grappe F, Rouillon JD. Application of force-velocity cycle ergometer test and vertical jump tests in the functional assessment of karate competitor. *J Sports Med Phys Fitness.* (2004) 44(4):349–55.
11. Chaabène H, Hachana Y, Franchini E, Mkaouer B, Chamari K. Physical and physiological profile of elite karate athletes. *Sports Med.* (2012) 42:829–43. doi: 10.1517/BF03262297
12. Loturco I, Artioli GG, Kopal R, Gil S, Franchini E. Predicting punching acceleration from selected strength and power variables in elite karate athletes: a multiple regression analysis. *J Strength Cond Res.* (2014) 28(7):1826–32. doi: 10.1519/JSC.0000000000000329
13. Ravier G, Dugué B, Grappe F, Rouillon JD. Impressive anaerobic adaptations in elite karate athletes due to few intensive intermittent sessions added to regular karate training. *Scand J Med Sci Sports.* (2009) 19(5):687–94. doi: 10.1111/j.1600-0838.2008.00807.x
14. Chaabene H, Hachana Y, Attia A, Mkaouer B, Chaabouni S, Chamari K. Relative and absolute reliability of karate specific aerobic test (KSAT) in experienced male athletes. *Biol Sport.* (2012) 29:211–5. doi: 10.5604/20831862.1003485
15. Ouerghi I, Hammouda O, Chtourou H, Gmada N, Franchini E. Effects of recovery type after a kickboxing match on blood lactate and performance in anaerobic tests. *Asian J Sports Med.* (2014) 5(2):99–107.
16. Čulár D, Ivančev V, Zagatto AM, Milič M, Beslija T, Sellami M, et al. Validity and reliability of the 30-s continuous jump for anaerobic power and capacity assessment in combat sport. *Front Physiol.* (2018) 9:543. doi: 10.3389/fphys.2018.00543
17. Inbar O, Bar-Or O, Skinner JS. *The Wingate Anaerobic Test*. Champaign, IL: Kinetics (1996).
18. Rydzik L, Niewczas M, Kedra A, Grymanowski J, Czarny W, Ambrozy T. Realization of indicators of technical and tactical training to demerits of kickboxers fighting in K1 formula. *Arch Budo Sci Martial Art Extreme Sport.* (2020) 16:1–5.
19. Rydzik L, Ambrozy T. The physical fitness and level of technical and tactical training of kickboxers. *Int J Environ Res.* (2021) 18:3088. doi: 10.3390/ijerph18063088
20. Ambrozy T, Rydzik L, Kwiatkowski A, Spieszny M, Ambrozy D, Rejman A, et al. Effect of crossfit training on physical fitness of kickboxers. *Int J Environ Res Public Health.* (2022) 19:4526. doi: 10.3390/ijerph19084526
21. Ruzbarsky P, Nema K, Kokinda M, Rydzik L, Ambrozy T. Comparison of selected characteristics of Slovak and Polish representatives in kickboxing. *Int J Environ Res Public Health.* (2022) 19:10507. doi: 10.3390/ijerph191710507
22. World Medical Association Declaration of Helsinki. Bratislava: State Institute for the Control of Medicines (2012). ŠUKL. Available online at: [https://www.sukl.sk/buxus/docs/Klinicke\\_skusanie\\_liekov/Pokyny/Helsinska\\_deklaracia\\_2008\\_EN\\_SK.pdf](https://www.sukl.sk/buxus/docs/Klinicke_skusanie_liekov/Pokyny/Helsinska_deklaracia_2008_EN_SK.pdf) (Accessed March 3, 2023).
23. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates (1988).
24. Roschel H, Batista M, Monteiro R, Bertuzzi RC, Barroso R, Loturco I, et al. Association between neuromuscular tests and kumite performance on the Brazilian karate national team. *J Sports Sci Med.* (2009) 8:20–4.
25. Pozo J, Bastien G, Dierick F. Execution time, kinetics, and kinematics of the mae-geri kick: comparison of national and international standard karate athletes. *J Sports Sci.* (2011) 29(14):1553–61. doi: 10.1080/02640414.2011.605164
26. Chaabène H, Franchini E, Miarka B, Selmi MA, Mkaouer B, Chamari K. Time-motion analysis and physiological responses to karate official combat sessions: is there a difference between winners and defeated karatekas? *Int J Sports Physiol Perform.* (2014) 9(2):302–8. doi: 10.1123/ijsspp.2012-0353
27. Saenko V. Improvement and control of the development level of special endurance in athletes of high qualification in kyokushin kiai karate. *In J Pharm Tech.* (2016) 8(3):18026–42.
28. Ojeda-Aravena A, Herrera-Valenzuela T, García JMG. Six weeks of HIIT based on repeated 5-meter sprints vs. countermovement jumps: effects on physical performance among karate athletes. A pilot-study. *Ido Mov Culture.* (2020) 20(2):24–32. doi: 10.14589/ido.20.2.4
29. Silva JF da, Aguiar JA, Moya CAM, Correia MGA Junior, Gomes WS dos, Oliveira VMA de, et al. Association between body composition and aerobic capacity in karate athletes. *Revista Brasileira De Cineantropometria Desempenho Humano.* (2022) 22:e71989. doi: 10.1590/1980-0037.2020v22e71989
30. Hausen M, Freire R, Machado AB, Pereira GR, Millet GP. Maximal and submaximal cardiorespiratory responses to a novel graded karate test. *J Sports Sci Med.* (2021) 20:310–6. doi: 10.52082/jssm.2021.310
31. Ouerghi I, Houcine N, Marzouki H, Davis P, Zaouali M, Franchini E, et al. Development of a noncontact kickboxing circuit training protocol that simulates elite male kickboxing competition. *J Strength Cond Res.* (2015) 29(12):3405–11. doi: 10.1519/JSC.0000000000001005
32. Ouerghi I, Davis P, Houcine N, Marzouki H, Zaouali M, Franchini E, et al. Hormonal, physiological, and physical performance during simulated kickboxing combat: differences between winners and losers. *Int J Sports Physiol Perform.* (2016) 11(4):425–31. doi: 10.1123/ijsspp.2015-0052
33. Crisafulli A, Vitelli S, Cappai I, Milia R, Tocco F, Melis F, et al. Physiological responses and energy cost during a simulation of a Muay Thai boxing match. *Appl Physiol Nutr Metab.* (2009) 34(2):143–50. doi: 10.1139/H09-002
34. Cappai IC, Pierantozzi E, Tam E, Tocco F, Angius L, Milia R, et al. Physiological responses and match analysis of Muay Thai fighting. *Int J Perform Anal Sport.* (2012) 12:507–16. doi: 10.1080/24748668.2012.11868615
35. Slimani M, Znazen H, Sellami M, Davis P. Heart rate monitoring during combat sports matches: a brief review. *Int J Perform Anal Sport.* (2018) 18(2):273–92. doi: 10.1080/24748668.2018.1469080
36. Janssen P. *Lactate Threshold Training*. Champaign, IL: Human kinetics Publisher (2001).
37. Sheppard JM, Gabbett T, Taylor KL, Dorman J, Lebedew AJ, Borgeaud R. Development of a repeated-effort test for elite men's volleyball. *Int J Sports Physiol Perform.* (2007) 2(3):292–304. doi: 10.1123/ijsspp.2.3.292
38. Draper N, Brent S, Hale B, Coleman I. The influence of sampling site and assay method on lactate concentration in response to rock climbing. *Eur J Appl Physiol.* (2006) 98(4):363–72. doi: 10.1007/s00421-006-0289-3
39. Alp M, Gorur B. Comparison of explosive strength and anaerobic power performance of taekwondo and karate athletes. *J Educ Learn.* (2020) 9:149–55. doi: 10.5539/jel.v9n1p149
40. Néma K, Ružbarský P. Relationships between selected performance parameters and body composition in karate. *J Kinesiol Exerc Sci.* (2023) 33(104):18–24. doi: 10.5604/01.3001.0053.9658
41. Rezaei M, Parnow A, Mohr M. Additional high intensity intermittent training improves aerobic and anaerobic performance in elite karate athletes. *Sport Sci Health.* (2024) 20(1):235–40. doi: 10.1007/s11332-023-01156-7
42. Sánchez-Puccini MB, Argothy-Bucheli R, Meneses-Echavez JF, López-Álban CA, Ramírez-Vélez R. Anthropometric and physical fitness characterization of male elite karate athletes. *Int J Morph.* (2014) 32:1026–31. doi: 10.4067/S0717-95022014000300045
43. Taati B, Arazi H, Bridge CA, Franchini E. A new taekwondo-specific field test for estimating aerobic power, anaerobic fitness, and agility performance. *PLoS One.* (2022) 17:3. doi: 10.1371/journal.pone.0264910
44. Paulo Lopes-Silva J, Panissa VL, Julio UF, Franchini E. Influence of physical fitness on special judo fitness test performance: a multiple linear regression analysis. *J Strength Cond Res.* (2021) 35(6):1732–8. doi: 10.1519/JSC.0000000000002948
45. Lovell DI, Bousson M, McLellan C. The use of performance tests for the physiological monitoring of training in combat sports: a case study of a world ranked mixed martial arts fighter. *J Athl Enhanc.* (2013) 2:1. doi: 10.4172/2324-9080.1000104
46. Ružbarský P, Néma K, Perič T, Ambrozy T, Bak R, Niewczas M, et al. Physical and physiological characteristics of kickboxers: a systematic review. *Arch Budo.* (2022) 18:111–20.
47. Bayraktaroglu S, Can I, Sadik S. The relationship between repeated sprint performance and velocity values during loaded-squat jump exercise. *J Educ Learn.* (2018) 2:280–6. doi: 10.5539/jel.v7n2p280
48. Coppin E, Heath EM, Bressel E, Wagner DR. Wingate anaerobic test reference values for male power athletes. *Int J Sports Physiol Perform.* (2012) 7(3):232–6. doi: 10.1123/ijsspp.7.3.232



## OPEN ACCESS

## EDITED BY

Alex Ojeda-Aravena,  
Pontificia Universidad Católica de  
Valparaíso, Chile

## REVIEWED BY

Shinji Yamamoto,  
Nihon Fukushi University, Japan  
Pierluigi Diotaiuti,  
University of Cassino, Italy

## \*CORRESPONDENCE

Qianchun Yu  
✉ yqspring@163.com

RECEIVED 15 March 2024

ACCEPTED 12 August 2024

PUBLISHED 23 September 2024

## CITATION

Teng Y, Wu H, Zhou X, Li F, Dong Z, Wang H,  
Wang K and Yu Q (2024) Neuropsychological  
impact of Sanda training on athlete attention  
performance. *Front. Psychol.* 15:1400835.  
doi: 10.3389/fpsyg.2024.1400835

## COPYRIGHT

© 2024 Teng, Wu, Zhou, Li, Dong, Wang,  
Wang and Yu. This is an open-access article  
distributed under the terms of the [Creative  
Commons Attribution License \(CC BY\)](#). The  
use, distribution or reproduction in other  
forums is permitted, provided the original  
author(s) and the copyright owner(s) are  
credited and that the original publication in  
this journal is cited, in accordance with  
accepted academic practice. No use,  
distribution or reproduction is permitted  
which does not comply with these terms.

# Neuropsychological impact of Sanda training on athlete attention performance

Yuzhu Teng<sup>1</sup>, Hailan Wu<sup>2</sup>, Xiaoyun Zhou<sup>2</sup>, Feiyang Li<sup>2</sup>,  
Zhong Dong<sup>3</sup>, Huafeng Wang<sup>4</sup>, Kai Wang<sup>3</sup> and Qianchun Yu<sup>5,6\*</sup>

<sup>1</sup>Department of Maternal, Child and Adolescent Health, School of Public Health, Anhui Medical University, Hefei, Anhui, China, <sup>2</sup>Department of Social Medicine and Health Service Management, School of Health Management, Anhui Medical University, Hefei, Anhui, China, <sup>3</sup>Department of Neurology, The First Affiliated Hospital of Anhui Medical University, Hefei, Anhui, China, <sup>4</sup>Sanda Teaching and Research Office, Wushu College, Beijing Sport University, Beijing, China, <sup>5</sup>Department of Health Information, School of Health Management, Anhui Medical University, Hefei, Anhui, China, <sup>6</sup>Sports Human Science Research Center, School of Humanistic Medicine, Anhui Medical University, Hefei, Anhui, China

**Background:** Sanda, a martial art that primarily involves punching, kicking, and throwing techniques, requires athletes to maintain high levels of concentration during combat. Sanda principally involves striking the opponent to secure victory, with trauma frequently occurring to the head; however, it remains unclear whether prolonged training enhances or impairs the athletes' attentional capacities. This study aimed to investigate the impact of Sanda training on athletes' attention by employing attention network tests.

**Methods:** A retrospective analysis was conducted on 37 professional Sanda athletes from a certain sports academy; 38 college students from the same institution majoring in physical education were recruited as the control group. Control participants had no prior experience in Sanda training, and the Sanda and control groups were matched in terms of sex, age, and education level. The Attention Network Test (ANT) was administered to both groups to compare differences in efficiency across the alerting, orienting, and executive control networks.

**Results:** Compared to the control group, the Sanda athletes exhibited significantly higher executive control network efficiency values and executive control network efficiency ratios ( $P < 0.05$ ). There were no significant differences between the Sanda group and the control group regarding the efficiency values of the alerting and orienting networks ( $P > 0.05$ ). Additionally, total accuracy and total reaction time between the Sanda athletes and control participants showed no statistically significant differences ( $P > 0.05$ ).

**Conclusion:** Sanda practice has detrimental effects on attention, including a decrease in the efficiency of the executive control network and a prolongation of the total reaction time. Therefore, athletes should improve attention training and use head protection to prevent frequent head impacts during training.

## KEYWORDS

Sanda, executive control, attention networks, neuropsychological assessment, cognitive function



# 1 Introduction

Sanda (Chinese kickboxing) is a hand-to-hand combat sport that utilizes punches, kicks, and wrestling techniques. The rapid and frequent transitions between attack and defense in competition require the athlete to concentrate on accurate and rapid reactions. Attention forms the basis of a sparring athlete's response to an opponent's punches and kicks; it is a preparatory attentional state for an anticipated cognitive or behavioral activity. During combat, the athletes' cognitive systems must respond to various stimuli as quickly as possible to ensure victory. Therefore, good athletes should have a good attention span. Angelini (2008) performed transcranial magnetic simulations on athletes and non-athletes, and found that the athletes responded more strongly when their motor areas were stimulated when compared to controls. However, as the head and face score higher than the trunk in the rules of sparring, the head and face are the most important parts of the body for effective striking, resulting in more injuries to the head (Fang, 2013). Specific attentional network deficits have been reported in people who have suffered mild traumatic brain injuries including concussion symptoms (Wang et al., 2023). The attentional changes in professional Sanda athletes who have undergone long-term training are unclear. Whether attention is improved by prolonged focused training or impaired by common sports injuries is worth investigating further.

In recent years, the association between physical activity and cognition has attracted the interest and attention of researchers in many fields. Attention is an important component of the cognitive processes. Attention was initially viewed as a single system; however, further exploration revealed that simple theoretical models do not account well for the processing of attention. Posner and Petersen (1990) proposed an attention network model based on a large number of cognitive neuroscience studies. This model structurally and functionally divides attention into three subsystems: alerting, orienting, and executive control. These three systems have different brain region localizations and relatively independent neural and biochemical systems; they are regarded as one of the most influential theoretical models of attention (Petersen and Posner, 2012; Posner, 2023; Klein et al., 2024). The alertness network maintains vigilance in preparation for receiving incoming information; it is associated with the frontal and parietal lobes of the right cerebral hemisphere and relies on the norepinephrine system. The orienting network selectively processes incoming information; it focuses on sensory events through spatially shifted attention, which is associated with the temporoparietal junctional area and the parietal lobule and relies on the cholinergic system. The executive control network develops plans, monitors and resolves conflict, and is associated with the anterior cingulate gyrus; it relies on the dopamine system (Davidson and Marrocco, 2000; Coull et al., 2001; Fan et al., 2003).

Fan et al. (2005) designed the Attention Network Test (ANT). It is an intuitive tool that is easy to use and employs both spatial cueing and lateral inhibition. Spatial cueing examines the efficacy of the two loops, the alerting network, and the orienting network, whereas lateral inhibition examines the efficacy of the executive control network. The ANT can assess all three of these networks quantitatively and is now widely used in children with attention

deficit hyperactivity disorder, in Alzheimer's populations, and in normal populations (Ishigami et al., 2016; McDonough et al., 2019; Vázquez-Marrufo et al., 2019). All behavioral activities of the human body are governed by the central nervous system, including an athlete's understanding, mastery, and application of difficult techniques. Johnstone and Marí-Beffa (2018) assessed the effects of martial arts training on the alerting network, orienting network, and executive control network using the ANT. Adults with at least 2 years of martial arts training experience were selected as the experimental group for the study, covering a wide range of martial arts styles such as Karate, Taekwondo, Kickboxing, Jujitsu, Tai Chi, Judo, Thai Boxing, and Kung Fu. The results showed that, compared to the control group, the martial arts training group showed a significant improvement in performance on the alerting network. Although their study provides valuable insights, its population of mainly healthy adults with short training periods and the variety of martial arts styles covered may have led to results that are somewhat generalized and lacking in specificity. There is a lack of research related to the cognitive aspects of attentional changes in professional sparring athletes.

Neuropsychological (NP) testing is an objective measure of the brain's behavioral associations and is more sensitive to minor cognitive deficits than clinical examination. Therefore, this study aimed to investigate the impact of a specific martial arts style (Sanda training) on athletes' attention by employing ANTs. Prolonged and intense training may have a different effect on the attentional network than other martial arts styles. It was hypothesized that better attentional performance might be observed in athletes exposed to Sanda compared to controls.

## 2 Materials and methods

### 2.1 Participants

We randomly selected 37 players from the Beijing Sport University Sanda Team, which had won the National Sanda Championship, including 32 (86.5%) males and five (13.5%) females. There were 18 first-string players (15 males and three females) and 19 second-string players (17 males and two females), with an average age of  $22.5 \pm 1.8$  years and  $14.9 \pm 1.8$  years of education. The 37 athletes mentioned above were included in the Sanda group.

During the same period, 38 college students majoring in physical education who had never been exposed to Sanda were randomly selected at Beijing Sport University. There were 32 (84.2%) males and six (15.8%) females with a mean age of  $22.1 \pm 2.0$  years and  $15.3 \pm 1.5$  years of education. The above 38 students were included in the control group. The basic characteristics of all the participants in the study are shown in Table 1. There were no statistically significant differences between the two groups of participants in terms of sex ( $\chi^2 = 0.078$ ,  $P = 0.781$ ), age ( $t = -1.009$ ,  $P = 0.316$ ), and years of education ( $t = 1.178$ ,  $P = 0.243$ ).

Participants with any of the following conditions were excluded from the study: history of brain trauma, nervous system or mental illness, or previous concussion. None of the participants we



TABLE 1 Basic characteristics of included and excluded participants.

Basic characteristics	Sanda group ( <i>n</i> = 37)	Control group ( <i>n</i> = 38)	<i>P</i> -value
Age/years ( <i>M</i> ± <i>SD</i> )	22.5 ± 1.8	22.1 ± 2.0	0.316
<b>Sex</b>			
Male	32/86.5	32/84.2	0.781
Female	5/13.5	6/15.8	
<b>Ethnicity</b>			
			0.513
Han nationality	36/97.3	35/92.1	
Hui nationality	1/2.7	2/5.3	
Other nationalities	0/0	1/2.6	
Education levels/years ( <i>M</i> ± <i>SD</i> )	14.9 ± 1.8	15.3 ± 1.5	0.243
<b>Family monthly income per capita/yuan (<i>n</i>/%)</b>			
			0.749
<1,000	1/2.7	0/0.0	0.749
1,000–2,500	7/18.9	8/21.1	
2,501–4,000	15/40.5	17/44.7	
>4,000	14/37.8	13/34.2	
<b>Place of residence (<i>n</i>/%)</b>			
			0.062
Urban areas	33/89.2	35/92.1	
Rural areas	4/10.8	62/7.9	
Smoking ( <i>n</i> /%)	2/5.4	1/2.6	0.540
Alcohol drinking ( <i>n</i> /%)	4/10.8	7/18.4	0.352

included were excluded. The naked or corrected visual acuity of the participants were normal, and they were all right-handed.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Committee of Bio-Medical Ethics of Anhui Medical University (No: 82230093). Informed consent was obtained from all individual participants and legal guardians included in the study.

## 2.2 Study procedures

### 2.2.1 ANT

Attentional network function was assessed using the ANT in both the Sanda group and the control group. During the experiment, participants sat at a distance of 40 cm from the center of the computer screen, with their eyes fixed on the gaze point in the center of the screen and their fingers placed on the response keys of the keyboard, and were asked to correctly and quickly determine the direction of the target, i.e., whether the direction of the arrow

in the center was to the left or to the right, and to respond by pressing the corresponding key: if the arrow is to the left, press the “←” key; if the arrow is to the right, press the “→” key. For each trial, the center gaze point “+” was first presented for 400–1,600 ms, followed by the cue “\*” for 100 ms. The center gaze point was presented again for 400 ms alone, and finally, the target stimulus was presented in the center of the screen for no more than 2,700 ms (Figure 1). The target stimulus disappeared as soon as the participant responded by pressing a key.

The gaze point was presented in the center of the screen throughout the study. There were four types of cues (Figure 2): (1) no hint: only the center gaze point was present without hints; (2) center hint: a single hint was presented at the center gaze point; (3) double hint: the two hints were presented above and below the center gaze point; and (4) spatial hint: a single hint was presented above or below the center gaze point. No hint, center hint, and double hint could not predict the upcoming location of the target stimulus, whereas spatial hints could predict the location of the target stimulus (the target stimulus appeared at the spatial cue presentation). The target stimulus was a left- or right-facing arrow, flanked by two-line segments that were the same length as the target stimulus, with or without arrows. The target stimuli were categorized into three situations (Figure 3): (1) neutral: no arrows on either side of the line segments; (2) consistent: arrows on both sides of the line segments, pointing in the same direction as the target stimulus; and (3) inconsistent: arrows on both sides of the line segments, pointing in the direction opposite to the direction of the target stimulus.

The experiment consisted of 312 formal trials and 24 practice sessions. The participants were familiarized with the targets and interference terms involved in this study through feedback on both correct and incorrect results. The entire experiment lasted approximately 30 min and was divided into three phases, with subjects allowed to rest between each phase. Since the participants were affected by factors such as interference with hints and target states during the experiment, the correct and incorrect responses and times of the participants were recorded in real time, and the attentional network efficacy was assessed by determining the response time in different states.

### 2.2.2 Efficiency calculation for attention network

According to the ANT principle devised by Fan et al. (2002), attentional network efficiency can be calculated as follows: alerting network efficiency = response time (RT) no hint condition – RT double hint condition. This is because attention is more dispersed in the no hint condition, and the appearance of a double hint asterisk at the location where the target is likely to appear will cause attention to be focused on the location where the target will appear, which will result in a reduction in the RT (alerting effect); larger values suggests a stronger alerting effect. The orienting network efficiency was calculated as follows: orienting network efficiency = RT center hint condition – RT effective spatial hint condition. This is because the effective spatial hint will provide information about localization, i.e., the location where the target will appear, which has an orienting effect and will shorten the participant's RT; larger values suggest a higher

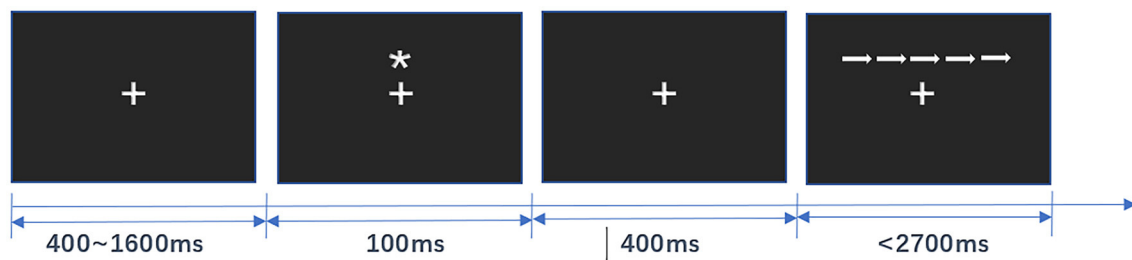


FIGURE 1  
Schematic diagram of the Attention Network Test (ANT) process.

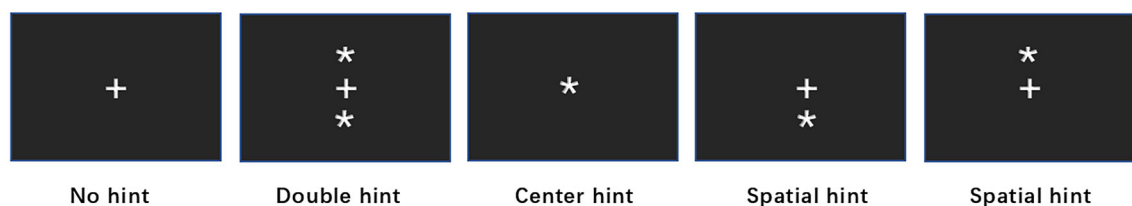


FIGURE 2  
Different hint states in the Attention Network Test (ANT).

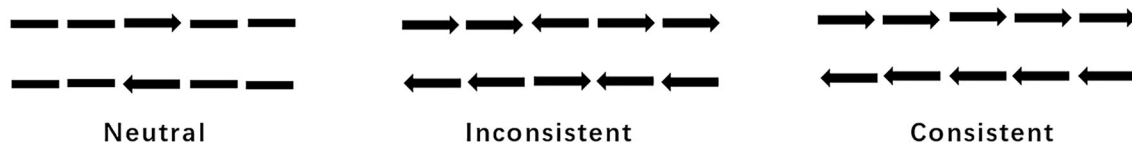


FIGURE 3  
Different target stimulus types in the Attention Network Test (ANT).

efficiency of the orienting network. Executive control network efficiency was calculated as follows: control network efficiency = RT direction inconsistent target stimulus condition – RT direction consistent target stimulus condition. When the direction of the target arrow is inconsistent with the surrounding arrows, the attentional network needs to resolve this conflict, extending the RT compared to the direction-consistent condition. Therefore, a small value suggests a strong executive control function, which is different from the first two network indicators. To exclude the possible effect of differences in total ANT reaction times, the efficiency ratio for each network was calculated separately as follows: efficiency ratio for each network = the efficiency value for that network (i.e., the difference in reaction times)/total reaction time. To confirm that the four cue types and three target stimulus conditions were appropriately manipulated in the experiment, the RT was collected for each cue type and target stimulus condition, and the mean RT and standard deviation were calculated. Differences in RTs across cue types and target stimulus conditions were compared.

## 2.3 Statistical analysis

Continuous variables are described as means and standard deviations, and categorical variables as numbers (percentages). The effects of cue type and target stimulus condition on RT were examined using the one-way ANOVA with *post hoc* tests using the Bonferroni method. The independent sample *t*-test was used to compare the ANT scores of the Sanda group and control group. Main effect sizes (ES) were presented as Hedges' *g* for *t*-test calculations. For the simple effect analysis, Hedges' *g* was used as the ES for small sample sizes with ranges of 0.2–0.6, 0.61–1.19, and 1.2, representing small, medium, and large effects (Hopkins et al., 2009). Generalized linear models were adopted to understand the association of Sanda sports with the athletes' attention network. Confounding factors were adjusted for in the models to test the robustness of the findings. Statistical Product and Service Solutions version 26.0 (Armonk, NY, USA) was utilized for data analyses.

TABLE 2 Effects of different cue types and target stimulus conditions on reaction time.

	Reaction time (ms; mean $\pm$ SD)	F-values	P-values	$\eta^2_p$
Types of cues		121.14	<0.001	0.021
No hint	652.9 $\pm$ 188.6			
Center hint	621.7 $\pm$ 177.8			
Double hint	608.3 $\pm$ 173.4			
Spatial hint	580.0 $\pm$ 178.2			
Situations of target stimuli		1,263.06	<0.001	0.128
Neutral	544.2 $\pm$ 167.6			
Consistent	601.5 $\pm$ 162.9			
Inconsistent	701.3 $\pm$ 177.4			

### 3 Results

#### 3.1 Effects of different cue types and target stimulus conditions on RT

There was a significant difference in the RT between the four cue types [ $F = 121.14$ ,  $P < 0.001$ , partial eta squared ( $\eta^2_p$ ) = 0.021; Table 2]. The *post hoc* testing suggested that the RT with no hint > RT with a center hint > RT with a double hint > RT with a spatial hint. It also showed a significant difference in the RT among the three target stimulus conditions ( $F = 1263.06$ ,  $P < 0.001$ ,  $\eta^2_p = 0.128$ ), with *post hoc* testing suggesting that the RT to the incongruent stimuli > RT to the congruent stimuli > RT to the neutral stimuli.

#### 3.2 Comparison of ANT between the Sanda and control groups

As shown in Figure 4, the results of the independent sample *t*-test showed that there was no significant difference between the alerting network efficiency [ $33.2 \pm 14.5$  vs.  $38.0 \pm 16.7$ , Hedges'  $g = 0.30$ , 95% confidence interval (CI):  $-0.15$  to  $0.76$ ], orienting network efficiency [ $44.4 \pm 14.3$  vs.  $47.1 \pm 19.1$ , Hedges'  $g = 0.16$ , 95% CI:  $-0.29$  to  $0.61$ ], total RT [ $585.8 \pm 45.0$  vs.  $568.9 \pm 40.6$ , Hedges'  $g = 0.40$ , 95% CI:  $-0.06$  to  $0.85$ ], and total accuracy [ $95.5 \pm 9.5$  vs.  $95.8 \pm 7.0$ , Hedges'  $g = 0.03$ , 95% CI:  $-0.42$  to  $0.49$ ] in the Sanda group compared to the control group (all  $P > 0.05$ ). The executive control network efficiency values were higher in the Sanda group than in the control group [ $114.2 \pm 26.8$  vs.  $82.6 \pm 27.3$ , Hedges'  $g = -1.17$ , 95% CI:  $-1.66$  to  $-0.68$ ,  $P < 0.05$ ]. Excluding the effect of the total RT, the executive control network efficiency ratio of the Sanda group was still higher than that of the control group [ $0.20 \pm 0.05$  vs.  $0.15 \pm 0.05$ , Hedges'  $g = -0.98$ , 95% CI:  $-1.46$  to  $-0.5$ ,  $P < 0.05$ ]. The alerting network efficiency ratio [ $0.06 \pm 0.03$  vs.  $0.07 \pm 0.03$ , Hedges'  $g = 0.36$ , 95% CI:  $-0.10$  to  $0.81$ ] and the orienting network efficiency ratio [ $0.08 \pm 0.02$  vs.  $0.08 \pm 0.03$ , Hedges'  $g = 0.26$ , 95% CI:  $-0.20$  to  $0.71$ ] in the Sanda group were not significantly different from those in the control group (both  $P > 0.05$ ).

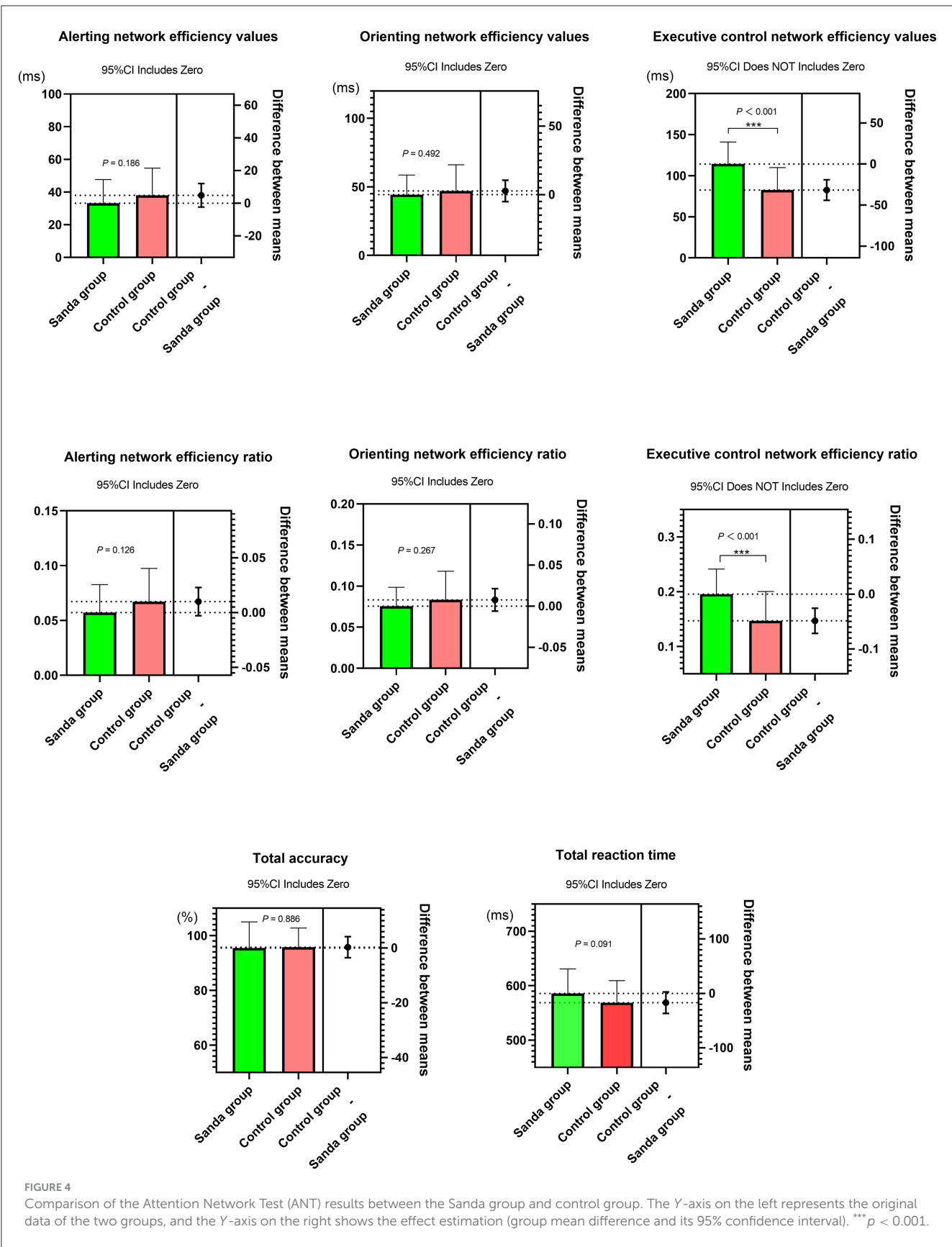
#### 3.3 Association between Sanda and attentional function

As shown in Table 3, without adjusting for any confounders (Model 1), the executive control network efficiency value was 31.66 (95% CI: 19.57–43.76) ms higher in the Sanda group compared to the control group, suggesting a decrease in executive control function. Excluding the effect of the total RT, the executive control network efficiency ratio was higher in the Sanda group compared to the control group ( $\beta = 0.05$ , 95% CI: 0.03–0.07). After adjusting for confounders (Model 2), the executive control network efficiency value was 34.11 (95% CI: 22.40–45.83) ms higher in the Sanda group compared to the control group. Higher executive control network efficiency ratios were observed in the Sanda group compared to the control group ( $\beta = 0.05$ , 95% CI: 0.03–0.08).

### 4 Discussion

This study revealed that exposure to the sport of Sanda may adversely affect the athletes' attentional network, as evidenced by elevated values of the executive control network efficiency, suggesting a decrease in executive control functioning. After excluding the effect of the total RT, the efficiency ratio of the executive control network remained higher in the Sanda group, indicating the stability of the results.

Attention is the process of pointing and focusing mental activity and consciousness on certain information or objects, in addition to the complex process of the appropriate allocation and processing of relevant sensory stimuli by the brain, which is a cognitive process. Whether exposure to Sanda affects an athlete's attention network remains controversial. Sanda requires focused attention during sparring, including scanning the opponent's body for scoring points, which requires the involvement of the alert network. Avoiding and blocking any incoming hit from the opponent requires orienting network efficiency for Sanda athletes. Furthermore, when the opponent uses feigned punches and kicks to distract attention, it is necessary to implement an executive control network to address the conflict. Johnstone and Mari-Beffa (2018) found that practitioners have a higher efficiency in their alerting networks than the control group when exploring the impact of



**TABLE 3** Generalized linear model for the association between Sanda and athletes' attention networks ( $\beta$  and 95% CI).

ANT	Sanda sports exposure	
	Model 1	Model 2
Alerting network efficiency values	−4.81 (−11.79 to 2.17)	−3.94 (−10.57 to 2.69)
Orienting network efficiency values	−2.70 (−10.26 to 4.86)	−3.38 (−10.94 to 4.18)
Executive control network efficiency values	31.66 (19.57 to 43.76)***	34.11 (22.40 to 45.83)***
Alerting network efficiency ratio	−0.01 (−0.02 to 0.00)	−0.01 (−0.02 to 0.00)
Orienting network efficiency ratio	−0.01 (−0.02 to 0.01)	−0.01 (−0.02 to 0.01)
Executive control network efficiency ratio	0.05 (0.03 to 0.07)***	0.05 (0.03 to 0.08)***
Total reaction time	16.92 (−2.20 to 36.03)	16.24 (−2.80 to 35.28)
Total accuracy	−0.28 (−4.01 to 3.45)	−1.00 (−4.39 to 2.38)

ANT, attention network test.

Model 1: unadjusted model.

Model 2: adjusted for age, sex, ethnicity, education levels, family monthly income per capita, place of residence, smoking and alcohol drinking history.

\*\*\* $P < 0.001$ .

extensive training in martial arts on cognitive control in adults. However, we observed no significant effect of long-term Sanda training on the alerting network. The reasons for the differences in these findings may lie in the differences in the martial arts styles, in addition to differences in the training intensity and years of training. A variety of martial arts styles were involved in the study by [Johnstone and Mari-Beffa's \(2018\)](#), of which Jujitsu, Tai Chi, and Judo typically do not involve or prohibit head strikes. In contrast, our study focused on Sanda athletes with frequent head strikes, which may have different effects on cognitive functioning. Additionally, the participants in the [Johnstone and Mari-Beffa \(2018\)](#) study were healthy adults with 2 years of training experience, whereas our study focused on professional Sanda athletes who had undergone more intense training over a longer period. Long-term, high-intensity training may lead to different changes in cognitive functioning in professional athletes than in short-term trainers. Although our study did not find a significant difference between the Sanda athletes and the control group in terms of the vigilance network efficiency, the mean values of the alerting network efficiency were lower in the Sanda athletes than in the control group ( $P > 0.05$ ). Our findings suggest that the potential damage associated with head blows in professional athletes under prolonged, high-intensity training may outweigh the improvement in their alertness from training. The influence of these factors needs to be explored in depth in further studies. Furthermore, Sanda is a contact sport where the practice of striking the head to score points exposes athletes to the cumulative effects of non-severe head injuries, such as sports concussions ([Prien et al., 2018](#)). [Howell et al. \(2013\)](#) found that concussion resulted in prolonged RTs on laboratory tests of attention and executive function for up to 2

months post-injury. Our study suggests that prolonged exposure to Sanda may cause a decrease in executive control functions and that Sanda athletes do not show a significant decrease in performance concerning the alerting network, orienting network, and RT.

The inconsistency in the findings could be attributed to the differences in the methods, sample sizes ([Noordzij et al., 2010](#)), and instruments used for assessing the athlete's neuropsychological development ([Merritt et al., 2017](#)). Interceptive sports, such as boxing, Sanda, table tennis, and archery, which require a high degree of body coordination or precise maneuvering with an instrument (e.g., bat or sword), have different effects on attentional regulation. In particular, an exploratory study has shown that archery can enhance attentional regulation ([Diotaiuti et al., 2021](#); [Lu et al., 2021](#)). In contrast, our previous study found that boxing may negatively affect cognitive function ([Teng et al., 2022](#)). Combined with the results of the current study, it is hypothesized that the effect of Sanda on attention may depend primarily on whether the athlete suffers a blow to the head, in addition to the frequency and intensity of the blow.

The mechanisms underlying the association between long-term exposure to sporadic fighting and declines in executive control function in athletes are unclear. Executive control function is closely related to the neural circuits regulated by the cingulate gyrus ([Uddin, 2021](#)). Neuroimaging techniques have shown that prolonged training in motor skills leads to a plastic reorganization of brain structure and function in professional athletes engaged in a variety of sports ([Huang et al., 2015](#)). A longitudinal study with a follow-up period of up to 1 year found that the cingulate cortex of combatants was significantly thinner than at baseline, which was accompanied by a decrease in N-acetyl aspartate metabolites ([Mayer et al., 2015](#)). Additionally, animal model studies have shown that repeated head blows result in greater neuropathological and neurobehavioral changes than a single head blow ([Kane et al., 2012](#)). Consequently, prolonged performance of combat sports, such as boxing practice, may affect the normal regulation of executive control functions by altering brain structure and function, in addition to adjusting the signaling molecules related to neurometabolism.

The strengths of this research are as follows. (1) The present study provides preliminary evidence on the effects of Sanda on attentional networks, with a particular focus on changes in the efficiency of executive control networks, filling a research gap on cognitive impacts in sports, particularly in the field of Sanda. (2) This study retrospectively analyzed professional Sanda athletes and compared them to a control group that had not been exposed to Sanda training. The controlled validity of the study design increases the likelihood of finding a causal association.

There are also some limitations to this study. First, this study had a retrospective design and cannot provide direct evidence of causality. Although athletes and controls were matched, some confounding factors could not be controlled for. Second, the frequency, intensity, and protection of blows to the head in the Sanda athletes were not recorded in detail, which may affect the precise interpretation of changes in attention.



## 5 Conclusion

In conclusion, the correct interpretation of neuropsychological test results can provide a basis for assessing changes in cognitive functioning in athletes during exercise. Therefore, this study suggests that neuropsychological testing can be used regularly in professional athletes to help identify and prevent early brain injuries that are difficult to recognize with instruments, in addition to the long-term complications.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by Committee of Bio-Medical Ethics of Anhui Medical University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

YT: Methodology, Writing – original draft. HWu: Validation, Writing – original draft. XZ: Writing – original draft, Data curation. FL: Writing – original draft, Software. ZD: Writing – original draft, Formal analysis, Investigation. HWa: Resources, Writing – review & editing. KW: Writing – review & editing, Supervision. QY: Writing – review & editing, Conceptualization, Data curation, Funding acquisition.

## References

- Angelini, J. R. (2008). How did the sport make you feel? Looking at the three dimensions of emotion through a gendered lens. *Sex Roles* 58, 127–135. doi: 10.1007/s11199-007-9229-x
- Coull, J. T., Nobre, A. C., and Frith, C. D. (2001). The noradrenergic alpha2 agonist clonidine modulates behavioural and neuroanatomical correlates of human attentional orienting and alerting. *Cereb. Cortex* 11, 73–84. doi: 10.1093/cercor/11.1.73
- Davidson, M. C., and Marrocco, R. T. (2000). Local infusion of scopolamine into intraparietal cortex slows covert orienting in rhesus monkeys. *J. Neurophysiol.* 83, 1536–1549. doi: 10.1152/jn.2000.83.3.1536
- Diotaiuti, P., Corrado, S., Mancone, S., Falese, L., Dominski, F. H., Andrade, A., et al. (2021). An exploratory pilot study on choking episodes in archery. *Front. Psychol.* 12:585477. doi: 10.3389/fpsyg.2021.585477
- Fan, J., Fossella, J., Sommer, T., Wu, Y., and Posner, M. I. (2003). Mapping the genetic variation of executive attention onto brain activity. *Proc. Natl. Acad. Sci. USA* 100, 7406–7411. doi: 10.1073/pnas.0732088100
- Fan, J., McCandliss, B. D., Fossella, J., Flombaum, J. I., and Posner, M. I. (2005). The activation of attentional networks. *Neuroimage* 26, 471–479. doi: 10.1016/j.neuroimage.2005.02.004
- Fan, J., McCandliss, B. D., Sommer, T., Raz, A., and Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *J. Cogn. Neurosci.* 14, 340–347. doi: 10.1162/089992902317361886
- Fang, S. H. (2013). Causes and prevention of common injuries in sanda sports. *Digit. User* 19, 122–123. doi: 10.3969/j.issn.1009-0843.2013.12.108
- Hopkins, W. G., Marshall, S. W., Batterham, A. M., and Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Med. Sci. Sports Exerc.* 41, 3–13. doi: 10.1249/MSS.0b013e31818cb278
- Howell, D., Osternig, L., Van Donkelaar, P., Mayr, U., and Chou, L. S. (2013). Effects of concussion on attention and executive function in adolescents. *Med. Sci. Sports Exerc.* 45, 1030–1037. doi: 10.1249/MSS.0b013e3182814595
- Huang, R., Lu, M., Song, Z., and Wang, J. (2015). Long-term intensive training induced brain structural changes in world class gymnasts. *Brain Struct. Funct.* 220, 625–644. doi: 10.1007/s00429-013-0677-5
- Ishigami, Y., Eskes, G. A., Tyndall, A. V., Longman, R. S., Drogos, L. L., Poulin, M. J., et al. (2016). The Attention Network Test-Interaction (ANT-I): reliability and validity in healthy older adults. *Exp. Brain Res.* 234, 815–827. doi: 10.1007/s00221-015-4493-4
- Johnstone, A., and Mari-Beffa, P. (2018). The effects of martial arts training on attentional networks in typical adults. *Front. Psychol.* 9:80. doi: 10.3389/fpsyg.2018.00080
- Kane, M. J., Angoa-Pérez, M., Briggs, D. I., Viano, D. C., Kreipke, C. W., Kuhn, D. M., et al. (2012). A mouse model of human repetitive mild traumatic brain injury. *J. Neurosci. Methods* 203, 41–49. doi: 10.1016/j.jneumeth.2011.09.003
- Klein, R. M., Good, S. R., and Christie, J. J. (2024). Changes in the networks of attention across the lifespan: a graphical meta-analysis. *J. Intell.* 12:19. doi: 10.3390/jintelligence1202019

## Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the Anhui Province Philosophy and Social Science Planning Project (AHSKF2019D032).

## Acknowledgments

We sincerely thank all the athletes of the Beijing Sport University Sanda team and students from the Physical Education program for their participation in this study. Additionally, we are grateful to HWa for providing professional materials related to Sanda and to KW for his guidance in neuropsychological testing.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- Lu, Q., Li, P., Wu, Q., Liu, X., and Wu, Y. (2021). Efficiency and enhancement in attention networks of elite shooting and archery athletes. *Front. Psychol.* 12:638822. doi: 10.3389/fpsyg.2021.638822
- Mayer, A. R., Ling, J. M., Dodd, A. B., Gasparovic, C., Klimaj, S. D., Meier, T. B., et al. (2015). A longitudinal assessment of structural and chemical alterations in mixed martial arts fighters. *J. Neurotrauma* 32, 1759–1767. doi: 10.1089/neu.2014.3833
- McDonough, I. M., Wood, M. M., and Miller, W. S. Jr. (2019). A review on the trajectory of attentional mechanisms in aging and the Alzheimer's disease continuum through the attention network test. *Yale J. Biol. Med.* 92, 37–51.
- Merritt, V. C., Meyer, J. E., Cadden, M. H., Roman, C. A., Ukueberuwa, D. M., Shapiro, M. D., et al. (2017). Normative data for a comprehensive neuropsychological test battery used in the assessment of sports-related concussion. *Arch. Clin. Neuropsychol.* 32, 168–183. doi: 10.1093/arclin/acw090
- Noordzij, M., Tripepi, G., Dekker, F. W., Zoccali, C., Tanck, M. W., Jager, K. J., et al. (2010). Sample size calculations: basic principles and common pitfalls. *Nephrol. Dial. Transplant* 25, 1388–1393. doi: 10.1093/ndt/gfp732
- Petersen, S. E., and Posner, M. I. (2012). The attention system of the human brain: 20 years after. *Annu. Rev. Neurosci.* 35, 73–89. doi: 10.1146/annurev-neuro-062111-150525
- Posner, M. I. (2023). The evolution and future development of attention networks. *J. Intell.* 11, 98. doi: 10.3390/jintelligence11060098
- Posner, M. I., and Petersen, S. E. (1990). The attention system of the human brain. *Annu. Rev. Neurosci.* 13, 25–42. doi: 10.1146/annurev.ne.13.030190.000325
- Prien, A., Grafe, A., Rössler, R., Junge, A., and Verhagen, E. (2018). Epidemiology of head injuries focusing on concussions in team contact sports: a systematic review. *Sports Med.* 48, 953–969. doi: 10.1007/s40279-017-0854-4
- Teng, Y., Yu, Q., Yu, X., Zhan, L., and Wang, K. (2022). Neuropsychological study on the effects of boxing upon athletes' memory. *J. Strength Cond. Res.* 36, 3462–3467. doi: 10.1519/JSC.0000000000003909
- Uddin, L. Q. (2021). Cognitive and behavioural flexibility: neural mechanisms and clinical considerations. *Nat. Rev. Neurosci.* 22, 167–179. doi: 10.1038/s41583-021-00428-w
- Vázquez-Marrufo, M., García-Valdecasas Colell, M., Galvao-Carmona, A., Sarrias-Arrabal, E., and Tirapu-Ustárrroz, J. (2019). The attention network test in the study of cognitive impairment of ADHD patients. *Rev. Neurol.* 69, 423–432. doi: 10.33588/rn.6910.2019202
- Wang, Y., Zhou, Y., Zhang, X., Wang, K., Chen, X., Cheng, H., et al. (2023). Orienting network impairment of attention in patients with mild traumatic brain injury. *Behav. Brain Res.* 437:114133. doi: 10.1016/j.bbr.2022.114133



## OPEN ACCESS

## EDITED BY

Lazar Toskić,  
University of Pristina, Serbia

## REVIEWED BY

Sasa Duric,  
American University of the Middle East, Kuwait  
Milan Markovic,  
University of Pristina, Serbia

## \*CORRESPONDENCE

QingLou Xu  
✉ 296723906@qq.com

RECEIVED 27 June 2024

ACCEPTED 13 September 2024

PUBLISHED 27 September 2024

## CITATION

Xu Q, Mao R and Xi C (2024) A comparative analysis of punching in boxing and sanda: kinematic differences based on the cross and uppercut.

Front. Sports Act. Living 6:1441470.  
doi: 10.3389/fspor.2024.1441470

## COPYRIGHT

© 2024 Xu, Mao and Xi. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# A comparative analysis of punching in boxing and sanda: kinematic differences based on the cross and uppercut

QingLou Xu<sup>1\*</sup>, Ruiqiu Mao<sup>2</sup> and Changjin Xi<sup>1</sup>

<sup>1</sup>Department of Physical Education, Zhejiang Guangsha Vocational and Technical University of Construction, Jinhua, Zhejiang, China, <sup>2</sup>Graduate Department, Shenyang Sport University, Shenyang, Liaoning, China

**Background:** This research aims to compare the differences in kinematic parameters associated with cross and uppercut punches between Sanda athletes (SA) and Boxing athletes (BA) to analyze their impacts on peak punching speed.

**Methods:** The punches of BA ( $n = 20$ ) and SA ( $n = 20$ ) were compared utilizing a three-dimensional (3D) framework and high-speed cameras in terms of 13 key parameters. An independent samples  $t$ -test ( $\alpha = 0.05$ ) was employed to analyze the differences in punching between BA and SA. Meanwhile, a stepwise multiple linear regression equation was developed to analyze the influence of selected parameters on peak punching speed.

**Results:** The results reveal that, among the 13 kinematic parameters, the six cross-related parameters and four uppercut-related parameters are significantly different (both  $p \leq 0.05$ ). The results of multivariate regression analysis unveils that the peak punching speed for the cross are influenced by the anteroposterior position of the center of gravity (in BA) and the maximum angular velocity of the shoulder (in SA). In contrast, for both BA and SA, the maximum angular velocity of the shoulder plays a critical impact on uppercut.

**Conclusions:** These findings indicate that trunk and upper limbs significantly influence the peak punching speed, which provides suggestions for daily training regimen of SA and BA as well as their coaches.

## KEYWORDS

combat sports, boxing, biomechanics, multivariate regression analysis, sanda

## 1 Introduction

Boxing and Sanda are combat sports that place a premium on both technical prowess and physical strength (1). During a match, athletes typically engage in a series of continuous punches, intricate footwork, and defensive maneuvers, to score points within 3-minute rounds. The fundamental techniques in Boxing and Sanda include straight punches, swing punches, and hook punches, which are further categorized into rear hand or lead hand punches based on the tactical scenario. The rear hand, located at the farthest position from the target, is renowned for delivering substantial force, while the lead hand occupying the closest position to the target can achieve maximum speed. Moreover, these techniques can be further distinguished into inside punches (rear hook and uppercut) and outside punches (jab and cross). The former earns its designation due to high efficacy at shorter distances within the opponent's punching range. In contrast, the straight punches like the jab/cross may not necessarily be inside the opponent's range, so they are categorized as outside punches. In a scenario where

two athletes maintain a typical non-attacking distance (about 1–1.5 meters), they often use jab because it is likely outside the opponent's range and can set up subsequent strategic opportunities. Recognizing these nuances in punching techniques is conducive to highlighting the importance of analyzing the kinematic performance of inside and outside punches, and then to enhance the understanding of athletes and coaches alike. Given that the Sanda was introduced at the 2008 Beijing Olympics and the number of participation in the Sanda in the sport worldwide is significantly increasing, it is crucial to investigate and understand the possible biomechanical differences between Sanda and Boxing.

Although numerous studies have delved into the punching performance, most of them were limited in biomechanical analysis (2, 3), so that it is hard to establish substantial assistance to athletes through interconnections among various quantitative data. Furthermore, most of these studies independently focus on male and female athletes and fail to reveal the potential differences in combat sports. This scarcity of empirical evidence poses a challenge for coaches and athletes to fully understand the approaches for enhancing punching performance based on kinematic analysis and to quantitatively assess the knowledge and information impacting the punching performance (2). In line with previous assessments of athletic techniques (4, 5), collecting kinematic data of the cross and uppercut and analyzing their impact on maximum punching speed can offer valuable insights into the complexity of inside and outside punch techniques. This, furthermore, assists in developing targeted intervention training specifically tailored for the cross and uppercut. In this research, a refined and efficient method was proposed to explore the differences in peak punching speed between Boxing athletes (BA) and Sanda athletes (SA), and a stepwise multiple linear regression equation was established to assess the impact of kinematic parameters on peak punching speed.

In summary, this research is developed to compare the kinematic performance of cross and uppercut punches between BA and SA using the biomechanical theory and to analyze the impact of kinematic parameters (independent variables) on punching speed (a dependent variable) through establishing a stepwise multiple linear regression equation.

The hypotheses in this research include (A) There are significant differences between BA and SA in kinematic performance (velocity parameters, center of gravity parameters, or angle parameters) in cross and uppercut; and (B) The center of gravity and upper limbs are determining factors of the maximum punching speed in crosses and uppercuts.

## 2 Materials and methods

### 2.1 Participants

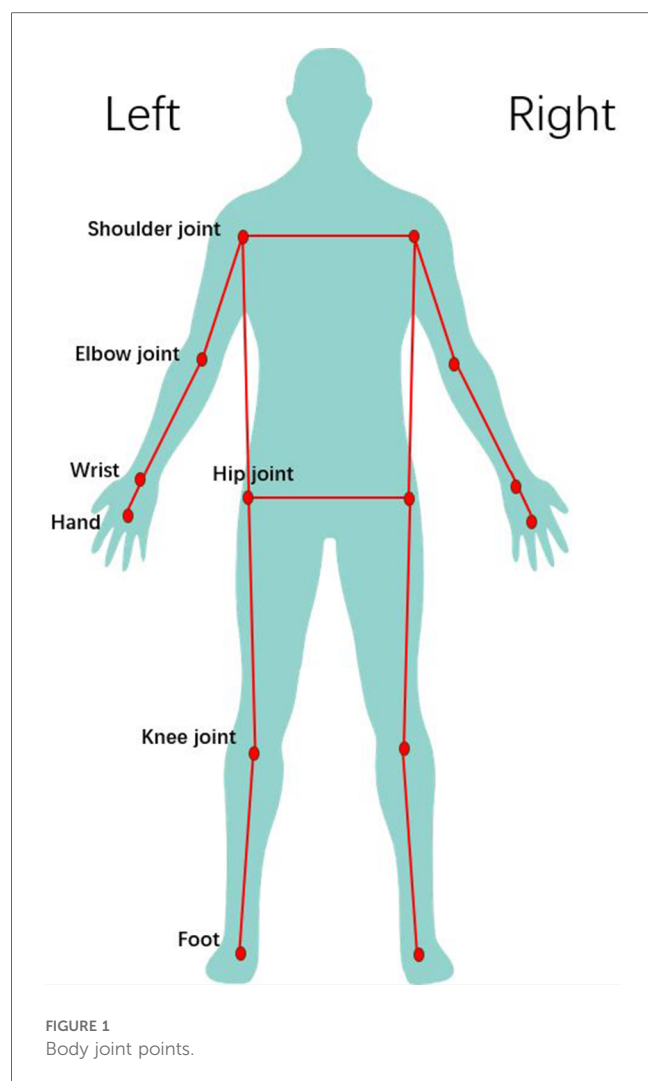
According to the G\*power sample size estimation software, Power = 0.8 and  $\alpha = 0.05$  were set in two groups, the total sample size was estimated to be 34, with 17 participants in each group. Actually, 20 BA and 20 SA at Shenyang Sport University were

recruited. The general data of BA are expressed in the form of mean  $\pm$  standard deviation (M  $\pm$  SD) as 19.41  $\pm$  0.69 years old, 173.2  $\pm$  7.4 cm, 64.7  $\pm$  10.9 kg, and 6.26  $\pm$  1.35 years of training, while those of the 20 SA are 19.38  $\pm$  0.76 years old, 169.5  $\pm$  7.1 cm, 59.8  $\pm$  11.1 kg, and 5.72  $\pm$  1.18 years of training. As the years of training showed, these participants have been immersed in comprehensive professional Boxing or Sanda training or coursework since their high school years or even earlier, boasting a track record of involvement in no fewer than 10 formal amateur or student matches, so they are proficient in cross and uppercut techniques. Prior to the experiment, their physical conditions were assessed to ensure they experienced no significant injuries in the past 6 months and no recent high-intensity training. Additionally, stringent measures were implemented to confirm they refrained from high-intensity training in the 24 h leading up to the tests, coupled with an ample rest period exceeding 8 h. This experiment was conducted in compliance with the *Declaration of Helsinki*, has obtained the written informed consents from all participants, and approved by the Ethics Committee of Shenyang Sport University [Ethics (2024) No. 12].

### 2.2 Experimental procedure

Two high-speed cameras (SONY HVR-V1C, manufactured in Japan) were employed to capture the punching dynamics of athletes in a fixed position. The cameras were positioned directly in front and to the right of the athletes, with a rapid shooting frequency of 200 Hz. Before and after the recordings, a 3D framework (013-c) was adopted for spatial position calibration (Figure 1). The calibrated 3D human motion analysis system adopted in this research was guaranteed with a high accuracy, with a relative error of less than 2% (6). The experimental procedures unfolded at the Boxing training facility of Shenyang Sport University, with a steadfast commitment to upholding the principles outlined in the *Declaration of Helsinki*. Prior to the commencement of the tests, athletes underwent thorough warm-up sessions, and the experimental procedures were diligently demonstrated to ensure a clear understanding. To ensure a more rigorous analysis of technical movements, all athletes were specifically instructed to use an orthodox (right-arm) stance during the punching. Throughout the tests, athletes maintained the positions calibrated by the 3D framework and executed three air punches for both the cross and uppercut with maximum force (without hitting a target). Notably, each punch originated from a standardized defensive posture, so that every successive punch can be continuously self-adjusted.

After capturing the footage, the obtained videos were analyzed using the ariel performance analysis system (APAS, USA). Specifically, 14 anatomical points on the body were selected for analysis (Figures 2, 3), and a low-pass filtering method (with a frequency of 10 Hz) was applied for smoothing. The punching process involves the sequential rotation of the torso, propelling the upper arm and forearm in the punching direction, so the punching action conforms to the principles of whip-like motion in the upper limb. The posture assumed during the punching greatly determines



the position of the center of mass related to the supporting surface, and dynamic changes in the center of mass are crucial for stability and flexibility of athletes. Joint angles during the punching process not only mirror the standardization of movement technique but also determine the effectiveness of hitting the target. In this research the kinematic performance of cross and uppercut among BA and SA were compared, and some parameters were examined, including the speed parameters, center of mass parameters, and angle parameters. During the punching, all joint angles were taken from the body joints on the right side, and all angular velocities were made from the horizontal plane/X-axis of the human body. The selected numerical values formed seven speed parameters, three angle parameters, and three center of mass parameters, as listed in Table 1 (7).

## 2.3 Statistical analysis

All kinematic data were descriptively statistically analyzed, expressed as  $M \pm SD$  and Kolmogorov-Smirnov (KS) normality tests ( $p \leq 0.05$ ). Subsequently, an independent samples *t*-test

( $\alpha = 0.05$ ) was employed to analyze the differences in punching between BA and SA. Finally, SPSS 25 was utilized for stepwise multiple regression analysis to establish a comprehensive multiple linear regression equation that identifies the primary factors influencing the dependent variable (hand\_v).

This method introduced all independent variables (12 in total) at once and tested and eliminated the variables that lost statistical significance to address the multicollinearity. Given the assumptions for establishing the multiple regression equation model, the Durbin-Watson (DW) value was reported for validation. After establishment, the multiple regression model was further corrected and tested. Ultimately, six optimal regression equations were provided, including the adjusted  $R^2$ , standard estimation error, F-value, Sig, DW value, and Beta value, for each equation.

## 3 Results

Tables 2, 3 present the kinematic performance. Tables 4–7 summarize the results of a multiple regression analysis.

### 3.1 Kinematic performance

As revealed in Tables 2, 3, the peak punching speed of the cross of the BA is 16.2% higher than that of SA ( $p \leq 0.05$ ), showing a significant difference. Significant differences are observed in maximum angular velocity of the shoulder ( $p \leq 0.05$ ) and maximum elbow flexion and extension angular velocity ( $p \leq 0.05$ ), while those in the other three angular velocities are not remarkable. Notably, BA have the highest angular velocity in the maximum angular velocity of the shoulder, while SA possess the highest angular velocity in the maximum trunk rotation angular velocity. The lowest angular velocity is observed for both BA and SA during the cross in the maximum angular velocity of the hip. In terms of center of gravity parameters, the three types of movements associated with the cross demonstrate a significant difference solely in the Y-axis range ( $p \leq 0.05$ ). The average Y-axis range for cross of BA surpasses that of the SA by 53.8%. Regarding angle parameters, differences are not significant in the maximum trunk rotation angle and shoulder joint angle during punching. The knee joint angle ( $p \leq 0.05$ ) and hip joint angle ( $p \leq 0.05$ ) are greatly different, with BA having a 4.7% greater knee joint angle than SA.

There exist substantial differences in the peak punching speed of the uppercut between BA and SA ( $p \leq 0.05$ ), with 11.3% higher for the BA. Among all the angular velocity parameters, only the maximum angular velocity of the hip, maximum torso rotation angular velocity and the maximum angular velocity of the shoulder are greatly different ( $p \leq 0.05$ ). The maximum angular velocity of the shoulder achieves the highest angular velocity parameter for BA, while that for SA is the maximum angular velocity of the hip. Furthermore, the lowest angular velocity parameter for both BA and SA is the maximum elbow joint angular velocity. Moreover, there are no



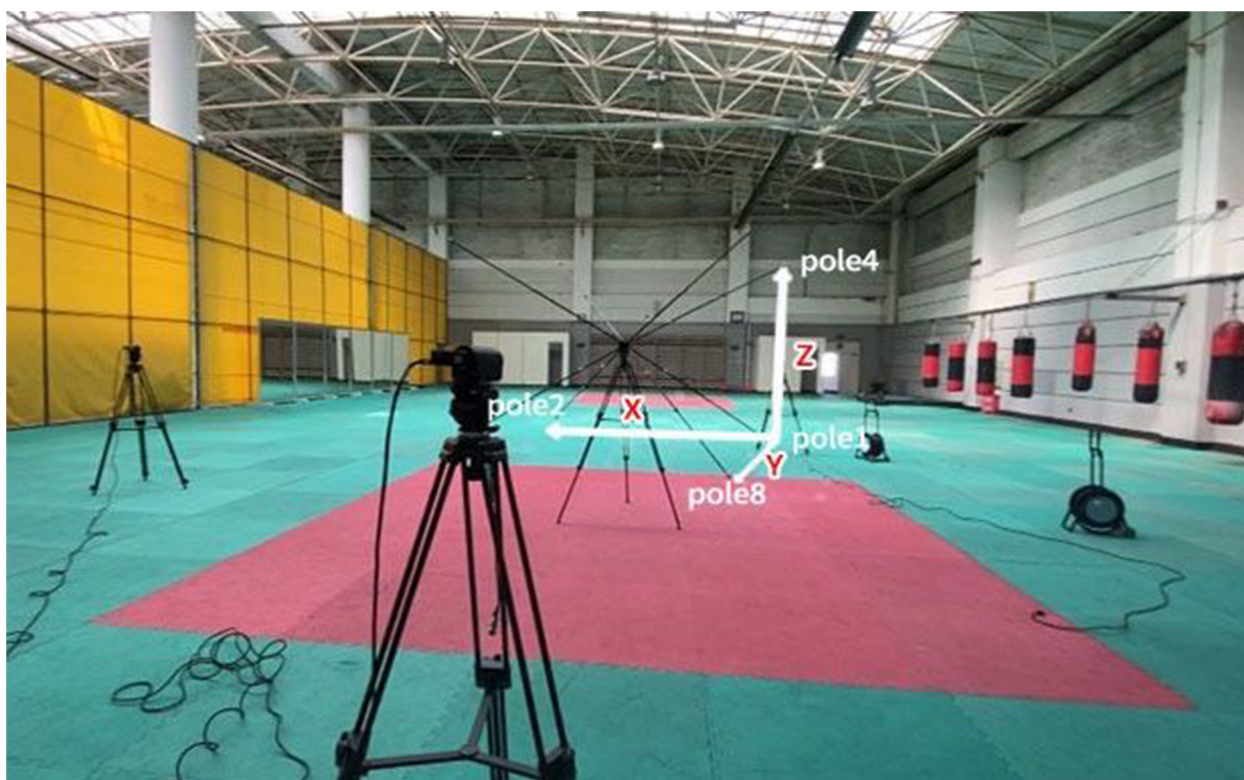


FIGURE 2  
The high-speed cameras and three-dimensional framework.

considerable differences in all seven parameters related to center of gravity and angle parameters.

## 3.2 Regression analysis

### 3.2.1 Cross

To temporarily circumvent the covariance, stepwise analysis can be employed to search the optimal combination of independent variables, and the most highly associated independent variables are automatically selected to enter into the model. As shown in Table 4, there are four independent variables in influence model of cross of BA, including  $\text{elbow\_}\omega$  (rad/s),  $\text{gravity\_X(mm)}$ ,  $\text{trunk\_}\omega$  (rad/s) and  $\text{shoulder joint\_}\omega$  (rad/s), which can explain 94.8% of the variance or 93.5% after adjustment. The statistical significance of this explanatory power, encompassing four independent variables, can be determined in the final equation on the basis of the F-test results [ $F(3,16) = 69.044$ ,  $p < 0.001$ ]. The equation is as follows:

$$Y = 0.382 + 0.646 \cdot \text{elbow\_}\omega(\text{rad/s}) + 0.725 \cdot \text{gravity\_Y(mm)} + 0.507 \cdot \text{trunk\_}\omega(\text{rad/s}) - 0.219 \cdot \text{shoulder joint\_}\omega(\text{rad/s}).$$

This equation was used for actual performance prediction, and the estimated standard error was 0.149. The coefficient estimation of the stepwise analysis (Bate) revealed that the order of factors influencing the peak punching speed of BA in cross is:  $\text{gravity\_Y(mm)} > \text{elbow\_}\omega$  (rad/s)  $> \text{trunk\_}\omega$  (rad/s)  $> \text{shoulder joint\_}\omega$  (rad/s).

Similarly, the results of the peak punching speed influence model of SA in cross are shown in Table 5, and the equation includes three independent variables, as follows (Estimated standard error=0.202):

$$Y = 4.706 + 0.376 \cdot \text{elbow\_}\omega(\text{rad/s}) + 0.406 \cdot \text{shoulder\_}\omega(\text{rad/s}) + 0.294 \cdot \text{trunk\_}\omega(\text{rad/s}).$$

The coefficient estimation of the stepwise analysis (Bate) reveals that the order of factors influencing the maximum punching speed of SA in cross is:  $\text{shoulder\_}\omega$  (rad/s)  $> \text{elbow\_}\omega$  (rad/s)  $> \text{trunk\_}\omega$  (rad/s).

### 3.2.2 Uppercut

The results of the peak punching speed influence model of BA in uppercut are shown in Table 6, and the equation as follows (Estimated standard error=0.496):

$$Y = 0.604 + 0.427 \cdot \text{shoulder\_}\omega(\text{rad/s}) + 0.352 \cdot \text{gravity\_Y(mm)} + 0.313 \cdot \text{gravity\_Z(mm)}.$$

Factors influencing the maximum punching speed of BA in uppercut can be sequenced as follows:  $\text{shoulder\_}\omega$  (rad/s)  $> \text{gravity\_Y(mm)} > \text{gravity\_Z(mm)}$ .

The results of the peak punching speed influence model of SA in uppercut are shown in Table 7, and the equation as follows (Estimated standard error=0.619):  $Y = 6.684 + 0.405 \cdot \text{gravity\_Y(mm)} + 0.563 \cdot \text{shoulder\_}\omega$  (rad/s).

The order of factors influencing the maximum punching speed of SA in uppercut was:  $\text{shoulder\_}\omega$  (rad/s)  $> \text{gravity\_Y(mm)}$ .

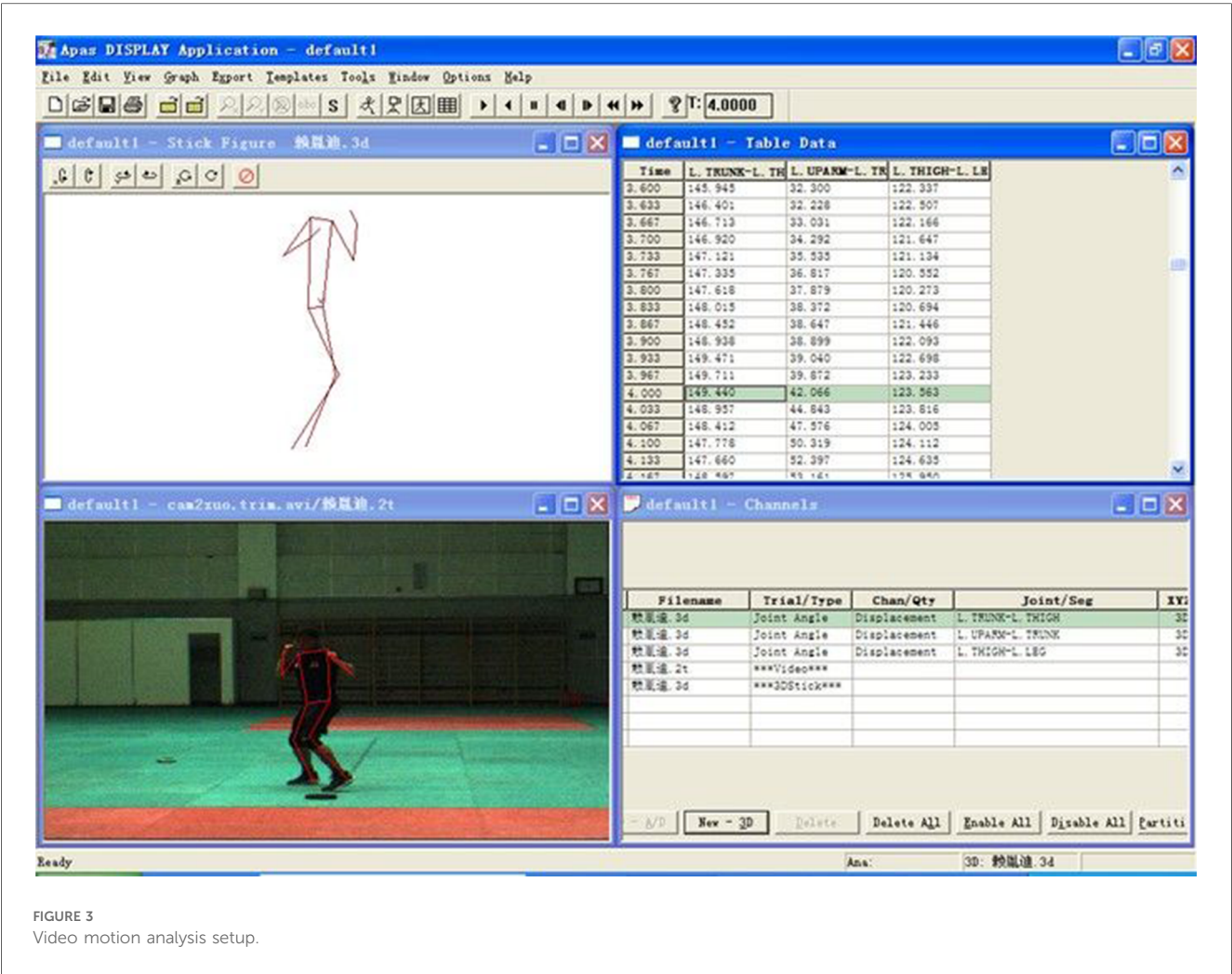


FIGURE 3  
Video motion analysis setup.

## 4 Discussion

### 4.1 Cross

Cross is categorized as an outside punch with a long reach and is frequently applied in matches despite having a lower hit rate. It serves as a primary method for scoring at mid-range and usually employed for counterattacks or as part of a combination of punches. As a result, it is of strategic significance in various match scenarios for BA and SA.

As depicted in Table 2, the peak punching speed for BA in cross is  $8.48 \pm 0.61$  m/s while  $7.30 \pm 0.49$  m/s for SA, which align with the findings of Piorkowski ( $8.22 \pm 0.68$  m/s) (3) and Kimm ( $7.70 \pm 1.50$  m/s) (8), respectively. Notably, BA have higher cross speed parameters in all aspects except for the maximum trunk rotation angular velocity. The maximum trunk rotation speed is crucially determined by the linear speed of hip and shoulder movements. Studies analyzing surface electromyographic data have demonstrated that the peak speed sequence for cross is 'hip-shoulder-elbow-wrist-hand' (9). Throughout the execution of the cross, the elbow joint rapidly extends forward under the influence of the shoulder joint. This action reduces the rotational

inertia of the upper limb around the longitudinal axis and increases the angular velocity of forearm internal rotation, thus facilitating the accumulation and utilization of elastic energy of the elbow joint muscle group. Therefore, a faster trunk rotation speed contributes to utilizing the energy from the lower limb segment and increasing the energy transfer from the proximal trunk segment to the distal shoulder joint segment. However, contrary studies have pointed out that the athletes, during the cross, exhibit a lower flexion-extension ratio of the knee joint and lower internal-external rotation ratio of the shoulder joint. This indicates that as angular velocity increases, there is a significant decrease in the flexor muscle strength of the knee joint and the internal-external rotation strength of the shoulder joint in athletes. Consequently, the flexion-extension and internal-external rotation ratios decrease notably, compromising the joint stability and elevating the risk of muscle strain among athletes. Therefore, the greater maximum trunk rotation angular velocity during cross of SA is inferred to propel the speed of other upper limb joints, contributing to an increased end punch speed. Moreover, this results in a greater maximum trunk rotation ( $0.92 \pm 0.29^\circ$ ) compared to BA. This is beneficial for utilizing the energy from the lower limb segment and highlights

TABLE 1 Various kinematic parameters.

	Parameters	Explanation
Velocity	Hand _v	Maximum punching speed refers to the line speed of the hand
	Shoulder _ω	Maximum shoulder angular velocity refers to the change in the angle of projection of the angle formed by the line joining the two shoulders on the horizontal plane per unit time
	Trunk _ω	Maximum torso rotation angular velocity refers to the change in torso rotation angle per unit time
	Waist _ω	Maximum hip angular velocity refers to the change in the angle of projection of the angle formed by the line joining the two hips on the horizontal plane per unit of time
	Elbow_ω	Maximum elbow flexion and extension angular velocity refers to the change in the angle between the upper arm and the forearm per unit of time
	Shoulder joint_ω	Maximum shoulder joint angular velocity refers to the change in the angle between the upper arm and the human torso per unit of time
Center of mass	Gravity _X	Range of movement of the body's center of gravity along the X-axis
	Gravity _Y	Range of movement of the body's center of gravity along the Y-axis
	Gravity _Z	Range of movement of the body's center of gravity along the Z-axis
Angular	Trunk _θ	Maximum torso rotation angle refers to the angle between the shoulder joints and the hip joints projected on the horizontal plane
	Shoulder joint_θ	Shoulder joint angle of the maximum punching speed
	Hip_θ	Hip joint angle of the maximum punching speed
	Knee_θ	Knee joint angle of the maximum punching speed

All joint angles were taken from the body joint on the right side during punching, and all angular velocities were taken from the horizontal plane/X-axis of the human body.

TABLE 2 Comparison of kinematic performance on cross.

	SA( <i>n</i> = 20)	BA( <i>n</i> = 20)	<i>t</i>	<i>p</i>	<i>d</i>
Hand_v( <i>m/s</i> )	8.48 ± 0.61	7.30 ± 0.49	1.016	<0.01	2.132
Shoulder_ω( <i>rad/s</i> )	12.95 ± 1.12	11.55 ± 1.23	1.079	<0.01	1.190
Waist_ω( <i>rad/s</i> )	10.47 ± 1.17	10.40 ± 1.10	0.197	0.844	0.062
Trunk_ω( <i>rad/s</i> )	10.83 ± 1.63	11.64 ± 1.92	-1.433	0.144	-0.455
Elbow_ω( <i>rad/s</i> )	11.57 ± 1.85	10.44 ± 2.82	1.494	0.050	0.474
Sh_joint_ω( <i>rad/s</i> )	12.78 ± 4.70	11.48 ± 1.00	1.205	0.254	0.382
Gravity_X( <i>mm</i> )	117.90 ± 13.41	118.73 ± 42.52	-0.084	0.934	-0.026
Gravity_Y( <i>mm</i> )	85.56 ± 6.95	55.60 ± 20.20	6.271	<0.01	1.983
Gravity_Z( <i>mm</i> )	43.39 ± 5.51	47.37 ± 9.19	-1.580	0.127	-0.525
Trunk_θ(°)	0.81 ± 0.27	0.92 ± 0.29	-1.223	0.227	-0.393
Sho_joint_θ(°)	105.29 ± 1.44	105.53 ± 2.68	-0.346	0.707	-0.112
Hip_θ(°)	158.22 ± 1.26	156.97 ± 1.38	-1.804	<0.01	0.946
Knee_θ(°)	176.48 ± 0.71	168.49 ± 1.20	-0.31	<0.01	8.104

Italic values means *p* ≤ 0.05.

the trunk rotation decreases shoulder joint stability during punching, thereby increasing the risk of injury. Additionally, it necessitates increased mobilization of trunk muscles, thus reducing the punch quality. As a result, it is recommended that athletes prioritize strength training during punching exercises, with an emphasis on explosive power training and supplementary maximum strength training. This approach aims to optimize the efficiency of strength quality transfer to punching speed and reduce the risk of injury (10).

TABLE 3 Comparison of kinematic performance on uppercut.

	SA( <i>n</i> = 20)	BA( <i>n</i> = 20)	<i>t</i>	<i>p</i>	<i>d</i>
Hand_v( <i>m/s</i> )	11.00 ± 1.05	9.88 ± 1.11	0.370	<0.01	1.037
Shoulder_ω( <i>rad/s</i> )	12.88 ± 2.10	11.61 ± 3.04	1.543	0.131	0.486
Waist_ω( <i>rad/s</i> )	10.30 ± 1.65	12.20 ± 1.62	-3.690	<0.01	-1.162
Trunk_ω( <i>rad/s</i> )	8.89 ± 1.10	7.76 ± 1.54	2.657	0.016	0.844
Elbow_ω( <i>rad/s</i> )	6.37 ± 2.59	5.74 ± 2.92	0.725	0.328	0.228
Sh_joint_ω( <i>rad/s</i> )	10.92 ± 2.96	7.14 ± 4.43	3.176	<0.01	1.003
Gravity_X( <i>mm</i> )	88.76 ± 40.23	95.56 ± 41.49	-0.526	0.566	-0.166
Gravity_Y( <i>mm</i> )	90.26 ± 18.26	86.21 ± 23.26	0.612	0.542	0.194
Gravity_Z( <i>mm</i> )	56.94 ± 14.05	54.11 ± 11.62	0.693	0.531	0.219
Trunk_θ(°)	0.94 ± 0.22	0.86 ± 0.44	0.729	0.479	0.229
Sho_joint_θ(°)	65.32 ± 2.38	64.21 ± 3.22	0.982	0.158	0.392
Hip_θ(°)	158.39 ± 1.12	158.32 ± 0.96	0.218	0.826	0.067
Knee_θ(°)	152.65 ± 1.37	152.29 ± 1.65	0.754	0.430	0.237

Italic values means *p* ≤ 0.05.

The center of gravity movement range on the Y-axis of BA is greater than that of SA, indicating a more pronounced forward center of gravity. This forward displacement during punching, along with the transfer of more body mass forward, enhances the mass of proximal segments and increases the rotational inertia of trunk, thereby increasing the flexibility of the cross and accelerating its speed. However, this advantage comes at the expense of reduced stability on the Y-axis during punching and a longer path for retracting the punch. It is essential for athletes to exercise with caution when the cross is used during matches, as it can be easily exploited by the opponent, leading to a loss of initiative (11). Various studies utilizing diverse methods of center of gravity measurement have consistently proven that winners in combat sports show greater variation in their center of gravity position compared to losers (12). Punching standards (skill level) are positively correlated with external load (frequency of offensive and defensive actions). Thus, winning outcomes are associated with a high offensive frequency and a low defensive frequency. In this context, the motion range of the center of gravity is not only crucial for optimizing punching techniques but also for the overall outcome of combat sports like Boxing and Sanda.

The primary distinction in angle parameters is observed in the knee joint, which is a critical factor for effectively transferring leg thrust that subsequently propels force to the upper limbs. The push-off from the back leg also aids in initiating body movement during punching. Studies have demonstrated that, at the same angular velocity, the correlation coefficient of punching force between the front and rear hand straight punches and the knee joint surpasses that of the shoulder joint (10). Furthermore, an active leg push-off during the cross exerts a positive impact on punching speed (13). Notably, the knee joint angle of the same-side lower limb is greater in BA than in SA during the cross. It signifies a more substantial push-off, which enables a more efficient transfer of force upwards, thus contributing to increased punching power and speed. Additionally, a greater hip joint angle in BA results in an overall trunk rotation towards the Y-axis and shift of the body's center of gravity further forward, thus facilitating the effective transfer of energy from proximal to distal segments and enhancing punching speed. In addition, it



TABLE 4 Ba's model abstract of peak punching speed on cross.

Model	Estimated standard error	Adjusted R <sup>2</sup>	F	Sig.	Durbin-Watson
1	0.43933	0.433	15.511	0.001	2.2
2	0.34653	0.647	11.931	0.003	
3	0.19167	0.892	39.57	0.000	
4	0.14904	0.935	11.461	0.004	

Dependent variable: hand\_v. Predictive value a: elbow\_ω. Predictive value b: elbow\_ω; gravity\_Y. Predictive value c: elbow\_ω;gravity\_Y; trunk\_ω. Predictive value d: elbow\_ω;gravity\_Y; trunk\_ω; shoulder joint\_ω. Beta: elbow\_ω = 0.646, gravity\_Y = 0.725, trunk\_ω = 0.507, shoulder joint\_ω = 0.219.

TABLE 5 Sa's model abstract of peak punching speed on cross.

Model	Estimated standard error	Adjusted R <sup>2</sup>	F	Sig.	Durbin-Watson
1	0.27421	0.688	42.98	0.000	2.199
2	0.22652	0.787	9.377	0.007	
3	0.20158	0.832	5.468	0.033	

Dependent variable: hand\_v. Predictive value a: elbow\_ω. Predictive value b: elbow\_ω; shoulder\_ω. Predictive value c: elbow\_ω; shoulder\_ω;trunk\_ω. Beta: elbow\_ω = 0.376, shoulder\_ω = 0.406, trunk\_ω = 0.294.

contributes to the observed discrepancy in cross speed between BA and SA, signifying that, apart from differences in upper limb strength, lower limb strength plays a decisive role.

The outcomes of regression analysis results (Tables 4, 5) reveal that the factor influencing the maximum punching speed of BA in cross (gravity\_Y) is difference from that affecting SA in cross (shoulder\_ω). For SA, range of anteroposterior movement of the center of gravity is the primary factor affecting the maximum punching speed. Actually, it not only influences punching speed but also crucial in determining its stability and flexibility on the Y-axis. Relevant studies suggest that electromyographic characteristics of the cross movement involve early activation of the calf muscles and biceps femoris of the lower limb (14), with the anterior deltoid exhibiting the highest percentage of activation. Additionally (9), the integrated electromyographic value of the upper limb muscle group is greater than that of each muscle group in the lower limbs (15), suggesting a relatively higher muscle activation level in the upper limbs during the cross. Moreover, Daniel Dinu pointed out the significant contribution of the elbow joint in the upper

body to the cross (16). From this perspective, the result indicating that maximum punching speed of SA in cross is influenced by the maximum angular velocity of the shoulder appears more reasonable. Furthermore, the maximum elbow joint angular velocity and the maximum trunk rotation speed are secondary factors influencing the maximum punching speed of the cross. In this regard, the regression analysis results demonstrate a tendency toward consistency between the Boxing and Sanda. Therefore, both BA and SA are recommended to prioritize the development of upper limb strength in cross training. Besides, they should understand the positive effect of rapid shoulder rotation on the energy transfer between body segments, and improve the capacity for accumulation and utilization of elastic potential energy in the elbow joint muscle group. The characteristic speed overlay of the cross, involving sequential braking of the shoulder, elbow, and hand, necessitates the design of end-release training exercises to align with this pattern. Studies have indicated that a focused 6-week elastic resistance training regimen can effectively improve the coordination and cooperation of upper limb muscles, significantly increasing the peak speed of the cross (6%–11%;  $p < 0.01$ ) (17). Incorporating specific strength movements such as using a 30% RM single-arm push unilateral barbell and elastic resistance punching can target the triceps and anterior deltoid, leading to substantial improvements in upper limb strength development and punching speed (18). Moreover, attention should be directed towards the transmission of total body strength during the cross and the change in the body's center of gravity position to strengthen the stability of the center of gravity in the anteroposterior direction.

TABLE 6 Ba's model abstract of peak punching speed on uppercut.

Model	Estimated standard error	Adjusted R <sup>2</sup>	F	Sig.	Durbin-Watson
1	0.71374	0.542	23.493	0.000	1.859
2	0.54346	0.735	14.047	0.002	
3	0.49006	0.784	4.906	0.042	

Dependent variable: hand\_v. Predictive value a: shoulder\_ω. Predictive value b: shoulder\_ω; gravity\_Y. Predictive value c: shoulder\_ω; gravity\_Y; gravity\_Z. Beta:shoulder\_ω = 0.427, gravity\_Y = 0.352, gravity\_Z = 0.313.

TABLE 7 Sa's model abstract of peak punching speed on uppercut.

Model	Estimated standard error	Adjusted R <sup>2</sup>	F	Sig.	Durbin-Watson
1	0.7157	0.587	27.965	0.000	1.950
2	0.6169	0.693	7.232	0.016	

Dependent variable: hand\_v. Predictive value a: shoulder\_ω. Predictive value b: shoulder\_ω; gravity\_Y. Beta: shoulder\_ω = 0.563, gravity\_Y = 0.405.

## 4.2 Uppercut

The uppercut is classified as an inside punch, and it is distinguished by rapid and abrupt force generation and a short motion path. It is more complex in movement details and striking technique compared to the cross and hook, yet its striking power is equally formidable. Widely employed in close-quarters combat, the uppercut stands out as the most frequently used offensive technique, often resulting in knockouts.

As shown in Table 3, the maximum punching speed of the uppercut is greater than that of the cross, the same as the findings of Daniel Dinu (16). However, Stanley et al. pointed out that the uppercut exhibits a higher peak speed than both the cross and rearhook, introducing a contentious aspect (2). This may be attributed by potential discrepancies in the punching method (punching trajectory) and testing method (target punching vs. air punching). Furthermore, Stanley highlighted that the position of the punching arm relative to the center of mass during the uppercut made by BA might represent the optimal configuration for generating muscular torque at the shoulder joint. This observation aligns with the significant difference in the maximum shoulder joint angular velocity obtained in this research ( $p < 0.01$ ). Uppercut involves the elbow joint moving towards the target at a nearly fixed angle, while the shoulder joint rapidly flexes and extends in the sagittal plane, followed by abduction, protraction, and adduction. This explains the significantly greater maximum shoulder joint angular velocity compared to the maximum elbow joint angular velocity for the uppercut in this research.

Since the direction of the center of gravity movement during punching aligns with that of trunk rotation, the uppercut initiates its center of gravity movement towards the X-axis (left-right), followed by movement along the Y-axis (forward-backward) and Z-axis (up-down). Comparing the center of gravity differences between BA and SA during uppercut shows a smaller range of movement on the X-axis but a greater range on the Y-axis of the BA. This suggests that BA possess greater stability on the X-axis in comparison to that on the Y-axis, simultaneously amplifying forward inertia to enhance punching speed. However, the extent of movement of the center of gravity on the Z-axis during punching is contingent upon the timing of the final braking moment of the punch. Studies have demonstrated the strong electromyographic activity in the latissimus dorsi during the uppercut (19). This actively aims to achieve a greater impulse in the final punch segment through timely braking of the upper arm and forearm using the latissimus dorsi (19). Therefore, the timing of braking determines the position of the center of gravity on the Z-axis, the angle of the shoulder joint, and the magnitude of the final impulse during the punch. To some extent, the positions of the center of gravity on the Z-axis and the angle of the shoulder joint during the punch are directly correlated with punching speed and final impulse. This elucidates why BA have greater shoulder joint angles and maximum trunk rotation angles during uppercut and higher punching speeds. Despite being the least frequently employed technique in matches, the uppercut demonstrates a higher punching speed to the cross, boasts a vertical trajectory (moving below the opponent's line of sight), unpredictability (limited use in

matches), and immense impact force (20). Therefore, both coaches and athletes are encouraged to prioritize this technique and augment its application in training and competition.

Results of the multivariate regression analysis (Tables 6, 7) reveal that the *shoulder\_ω* significantly impacts the peak punching speed of both BA and SA in uppercut. It, subsequently, influences the changes in center of gravity in the anteroposterior and vertical directions. Considering the characteristics of combat sports, a stance with the feet positioned front to back and the front foot turned inward is favored to mitigate exposure to counterattacks, absorb anteroposterior impact forces, and satisfy the punching and foot movement. This stance enhances the stability and flexibility on the X-axis and Y-axis while increasing the likelihood of changes in the body's center of gravity. Prior research emphasizes the importance of enhancing maximum strength and speed of force application during the active push-off phase, both front and back, to boost the punching speed of the uppercut (21). Both BA and SA are recommended to prioritize the coordination of body center of gravity movement with active leg push-off during uppercut training. Meanwhile, emphasis should be placed on incorporating strength exercises targeting the core area. Additionally, during the training of uppercut, SA should pay particular attention to effective shoulder rotation and the timing of upper limb braking to enhance energy transfer from the proximal shoulder joint to the distal segments of the upper limb. In contrast, BA should focus on maintaining the alignment of the center of gravity with the direction of the punch, amplifying the movement of body mass in the direction of the punch to enhance punching speed.

## 5 Limitations

(1) The experimental environment is quite different from the competition or real-life punching environment, and the Hawthorne effect may occur during the testing, resulting in different punching results from the usual. Consequently, subsequent studies are hoped to comparatively analyze the punching situation under competition conditions. (2) The indicators selected in this research have some limitations, such as lacking in physiological, biochemical and kinetic parameters. As a result, future studies can be more refined to provide a comprehensive understanding of the punching phenomenon. (3) Low feasibility of inter-comparison and limited sample size affect the statistical results, which could be made more rigorous by having a larger sample size or a more rigorous statistical approach to comparative analysis.

## 6 Conclusions

Remarkable differences are observed in speed, center of gravity, and angle parameters of cross and uppercut performed by Boxing athletes and Sanda athletes. Boxing athletes generally outperform Sanda athletes in multiple speed parameters, while the center of gravity and angle parameters exhibit both similarities and differences. Furthermore, results in this research reveal that the



primary factors affecting punching speed are the trunk and upper limbs, with the lower limbs playing a predominant role in maintaining the overall body stability and providing appropriate push-off force for upward transmission.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Ethics statement

The studies involving humans were approved by Shenyang Sport University Ethics Committee(Shenyang Sport University). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

QX: Software, Writing – original draft, Writing – review & editing. RM: Methodology, Writing – review & editing. CX: Writing – review & editing, Data curation.

## References

- Liu Y, Li L, Yan X, He X, Zhao B. Biomechanics of the lead straight punch and related indexes between sanda fighters and boxers from the perspective of cross-border talent transfer. *Front Physiol.* (2023) 13:1099682. doi: 10.3389/fphys.2022.1099682
- Stanley E, Thomson E, Smith G, Lamb KL. An analysis of the three-dimensional kinetics and kinematics of maximal effort punches among amateur boxers. *Int J Perform Anal Sport.* (2018) 18(5):835–54. doi: 10.1080/24748668.2018.1525651
- Piorkowski BA, Lees A, Barton GJ. Single maximal versus combination punch kinematics. *Sports Biomech.* (2011) 10(1):1–11. doi: 10.1080/14763141.2010.547590
- Kageyama M, Sugiyama T, Takai Y, Kanehisa H, Maeda A. Kinematic and kinetic profiles of trunk and lower limbs during baseball pitching in collegiate pitchers. *J Sports Sci Med.* (2014) 13(4):742–50.
- Wagner H, Pfusterschmied J, Tilp M, Landlinger J, von Duvillard SP, Müller E. Upper-body kinematics in team-handball throw, tennis serve, and volleyball spike. *Scand J Med Sci Sports.* (2014) 24(2):345–54. doi: 10.1111/j.1600-0838.2012.01503.x
- Yang NF, Wang JJ, Huang CH, Wang RC, Jin DW. Influence of calibration on the accuracy of 3-D reconstruction in direct linear transformation algorithm. *J Tsinghua Univ (Sci Technol).* (2000) 40(4):24–7. doi: 10.16511/j.cnki.qhdxxb.2000.04.008
- Song ZM. *Analyzing the characteristics of the boxing punch and research on the influence of core strength training for boxing punch* (Dissertation thesis). Beijing Sport University, Beijing (2016).
- Kimm D, Thiel DV. Hand speed measurements in boxing. *Proc Eng.* (2015) 112:502–6. doi: 10.1016/j.proeng.2015.07.232
- Guo F, Zhang RH. Surface electromyography of upper extremity muscles for elite female boxers' straight punches. *J Shenyang Sport Univ.* (2009) 28(4):65–8. doi: 10.3969/j.issn.1004-0560.2009.04.017
- Zhou ZX, Wang DX, Chen C, Yi WJ. Study on the correlation between the isokinetic muscle strength of shoulder joint and knee joint of boxers and the strength of straight boxing. In: *Abstract Compilation of the 12th National Convention on Sports Science of China*; 2020 Mar 25–27; Rizhao, Beijing, China (2022). p. 8443–4. doi: 10.26914/c.cnkihy.2022.008894
- Ashker SE. Technical and tactical aspects that differentiate winning and losing performances in boxing. *Int J Perform Anal Sport.* (2011) 11(2):356–64. doi: 10.1080/24748668.2011.11868555
- Davis P, Wittekind A, Beneke R. Amateur boxing: activity profile of winners and losers. *Int J Sports Physiol Perform.* (2013) 8(1):84–91. doi: 10.1123/ijssp.8.1.84
- Su YJ, Wu YG, Yuan Y, Wu ZP. Effect of lower limb fast drive force on punch speed in back straight punch. *China Sport Sci Technol.* (2013) 49(2):118–22. doi: 10.16470/j.csst.2013.02.020
- Liu Y. *Study on the effect of unilateral and bilateral compound resistance training on the technical training of lead and rear straight punches of boxer* (Dissertation thesis). Shanghai University of Sport, Shanghai (2021). doi: 10.27315/d.cnki.gstyx.2021.000012
- Sun YR, Miao ZH. An analysis on the surface electromyography of excellent male sanda players' straight fist technique. *Chin Wushu Res.* (2018) 7(12):46–8.
- Dinu D, Millot B, Slawinski J, Louis J. An examination of the biomechanics of the cross, hook and uppercut between two elite boxing groups. *Proc AMLA Annu Fall Symp.* (2020) 49(1):61. doi: 10.3390/proceedings2020049061
- Markovic P, Suzovic D, Kasum G, Jaric S. Effects of training against elastic resistance on jab punch performance in elite junior athletes. *Kinesiology.* (2016) 48(1):79–86. doi: 10.26582/k.48.1.8
- Liu Y, Cheng LF, Wu Y, Zhu ZQ, Wang DX. Biomechanics of rear straight punch in different level boxers. *J Wuhan Inst Phys Educ.* (2020) 54(7):80–6. doi: 10.15930/j.cnki.wtxb.2020.07.011
- Yang YM. An analysis of female boxers' different punch technology based on surface mechanical and electrical technology. *Liaoning Sport Sci Technol.* (2016) 38(3):33–6. doi: 10.13940/j.cnki.lntykj.2016.03.012
- Slimani M, Chaabène H, Davis P, Franchini E, Cheour F, Chamari K. Performance aspects and physiological responses in male amateur boxing competitions: a brief review. *J Strength Cond Res.* (2017) 31(4):1132–41. doi: 10.1519/JSC.0000000000001643
- Su YJ, Wu YG, Yuan Y. Effect of lower limbs fast drive force on punch speed in back hook punch. *J Shandong Inst Phys Educ Sports.* (2013) 29(3):55–61. doi: 10.14104/j.cnki.1006-2076.2013.03.012

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Acknowledgments

The authors acknowledge RM for proofreading activity.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.



## OPEN ACCESS

## EDITED BY

Alex Ojeda-Aravena,  
Pontificia Universidad Católica de Valparaíso,  
Chile

## REVIEWED BY

George Jennings,  
Cardiff Metropolitan University,  
United Kingdom  
Radwan Kharabsheh,  
Hashemite University, Jordan

## \*CORRESPONDENCE

Benqian Li  
✉ libenqian@sjtu.edu.cn

RECEIVED 20 May 2024

ACCEPTED 07 October 2024

PUBLISHED 23 October 2024

## CITATION

Santanna EA and Li B (2024) Cultural hybridity and body image formation: exploring the experiences of Wushu male practitioners at the Siberian Chinese Martial Arts Center. *Front. Psychol.* 15:1435647. doi: 10.3389/fpsyg.2024.1435647

## COPYRIGHT

© 2024 Santanna and Li. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# Cultural hybridity and body image formation: exploring the experiences of Wushu male practitioners at the Siberian Chinese Martial Arts Center

Ekaterina A. Santanna and Benqian Li\*

School of Media and Communication, Shanghai Jiao Tong University, Shanghai, China

This study explores the formation of a hybrid body image among white cisgender males practicing Wushu at the Siberian Chinese Martial Arts Center. Grounded in Social Identity Theory and the concept of bicultural identity, the research employs narrative interviews with 12 participants. Thematic analysis revealed three main themes: the creation of a hybrid identity blending Chinese martial arts traditions with Russian cultural backgrounds, conceptualized as judanren; the challenges associated with this identity in both Russian and Chinese contexts; and the role of Wushu uniforms in reconciling these cultural contradictions, serving as a “second skin” for practitioners. The findings contribute to a more inclusive understanding of body image and identity formation in a multicultural, non-Western context.

## KEYWORDS

cultural hybridity, body image formation, Wushu male practitioners, thematic analysis, narrative interviews

## Introduction

The practice of martial arts has a profound impact not only on the physical condition of practitioners but also on their mental well-being (Bu et al., 2010). As mind–body practices, martial arts have been found to enhance self-confidence and shape self-body image (Pedrini and Jennings, 2021). Wushu, or Chinese martial arts, not only offers unique physical and mental exercises but also serves as a manifestation of Chinese traditional culture (Li and Dai, 2021). Rooted in ancient philosophy, Wushu embodies a unique understanding of the relationships between humans and nature, humans and others, and the connection between the mind and body (Theeboom and De Knop, 1997; Park and Bairner, 2023; Tzeng et al., 2023). Despite its Chinese culture orientation, Wushu has gained tremendous popularity worldwide (Han et al., 2023; Xue et al., 2023).

While there is a substantial body of literature on the health and mental health benefits of Wushu as a physical exercise (Wąsik and Wójcik, 2017; Moore et al., 2020), there is a dearth of studies that analyze the impact of Chinese traditional cultural elements within this martial art on participants’ perceptions of the practice and themselves.

This study addresses this gap by examining practitioners in Russia, particularly in Siberia.

In recent decades, Russia has increasingly oriented itself towards the East (Rodkiewicz, 2014), characterized by strengthened cooperation with China and a strategic distancing from the West, particularly following the invasion of Ukraine (Huang and Wang, 2024). This cultural shift is evident in various governmental initiatives that actively promote Chinese traditional culture through festivals, fairs, and other cultural events (Matveevskaya and Ren, 2023). Additionally, the growing popularity of Chinese cultural media, such as TV series, has

been driven by online communities (Zhou, 2021), resulting in heightened interest among Russians in learning Chinese, joining Chinese martial arts centers, and participating in traditional Chinese painting studios.

Although Siberia does not share a direct border with China, it holds significant cultural importance due to its historical connections and the presence of diverse ethnic groups, including the Buryats, Yakuts, Tuvians, Khakas, and Altaians. These communities contribute to a culturally rich landscape that resonates with elements of Chinese traditional culture.

Through this study, the experiences of Siberian Wushu practitioners will be explored, particularly regarding how their practice influences their body image perceptions.

## Theoretical framework

The theoretical framework employed in this study integrates two complementary perspectives: Social Identity Theory (Tajfel and Turner, 1985) and the concept of bicultural identity within Acculturation Theory (Berry, 1980). This framework provides insights into how body image is shaped by group dynamics and cultural integration. Social Identity Theory (Tajfel and Turner, 1985) posits that individuals derive significant aspects of their identity from their affiliations with social groups. This study applies this theory to examine the effects of participation in Wushu groups on practitioners' self-perceptions, elucidating the dynamics of body image within the martial arts context.

Furthermore, the concept of bicultural identity, as defined by Berry (1980, 1997), refers to individuals engaging with two distinct cultures, reflecting an integration strategy of acculturation. Benito-Martinez et al. (2002) elaborate on this by indicating that individuals synthesize elements from both their heritage and receiving cultures, resulting in a unique bicultural identity. This study specifically investigates how Wushu practitioners navigate their dual cultural affiliations—Chinese traditional practices and their Russian environment—and how these affiliations influence their body image perceptions.

## Method

As noted by Landor et al. (2024), previous research on body image has predominantly focused on Euro-American samples and primarily employed quantitative methodologies. To expand this scope, the present study aims to explore body image perspectives among a unique group of Wushu practitioners in Siberia through a qualitative approach. Jennings (2010) advocates for the use of qualitative methods, particularly life history interviews, as effective tools for understanding the transformations individuals undergo through long-term practice of traditional Chinese martial arts.

In line with this approach, narrative interviews were selected as the primary method for data collection due to their capacity to capture in-depth, contextually rich, and participant-centered accounts that reveal individual experiences and cultural meanings (Holmqvist and Frisén, 2010). These interviews addressed a broad range of questions that aligned with the theoretical framework, covering general experiences in Wushu practice with fellow practitioners, as well as

specific inquiries about self-perception and body image during practice and in everyday life.

## Context of study

The Siberian Chinese Martial Arts Center is an independent facility founded by Russian Wushu practitioners who have studied in China. These practitioners are proficient in Chinese and, after establishing the center in Russia, maintain connections with their masters to organize joint events in both Russia and China. The center emphasizes that martial arts practice extends beyond physical exercises, encompassing the philosophy of Wushu and Chan Buddhism. The goal is to strengthen not only the body but also to achieve inner peace and harmony with oneself and the world. Regular discussions and question-and-answer sessions about all aspects of practice often follow classes in the kwoon rooms.

At the center, individuals can also engage in various activities, including Wushu and Qigong classes, meditation sessions, Chinese language lessons, and the exploration of Chinese calligraphy and traditional Guohua painting. Additionally, there is a recreation zone where visitors can enjoy Chinese tea, listen to traditional Chinese music, or play Xiangqi (Chinese chess) after classes. The center also serves as a venue for celebrating Chinese holidays together. To deepen their understanding of Chinese culture, participants can take part in master classes on Chinese cuisine, traditional knotting, or shadow theater.

## Participants

All participants were recruited through advertising and researcher invitations during training sessions at the Siberian Chinese Martial Arts Center. Jennings (2010) notes that “four years is a typical period for a student to progress from a beginner to senior student and possibly even assistant instructor status within a school” (p. 26). This aligns with the program structure at the center, where students spend their first year learning basic concepts and foundational elements before mastering the first taolu complexes, which include various movements, transitions, punches, and stances.

Although students' progress at varying speeds and possess different abilities, deep immersion in Wushu practice generally does not commence until after at least one year of practice. As a result, one year of practice was established as the minimum criterion for participation in this study. However, while individuals with approximately one year of practice were eligible, only those with a minimum of two years of training chose to participate, reflecting a greater commitment to their training and readiness to engage in the research.

Moreover, despite invitations being extended to participants of all genders in the Wushu classes, only male participants opted to take part in the study. Consequently, the sample comprised twelve cisgender males who voluntarily agreed to participate. All participants were Russian citizens and identified as white. Their ages ranged from 27 to 55, with a mean age of 36.2 (SD=8.2). The participants' experience in Wushu varied from 2 to 20 years, with one individual practicing for 20 years, two individuals for 10 years, and the remaining participants for periods between 2 to 5 years.

In terms of education, ten out of the twelve participants had a higher education background. Regarding income, seven participants had a middle income, while five participants had a low income. Marital status varied among the participants, with six participants being married with children, two being married without children, and four being single.

All participants had visited China, with two of them having participated in Wushu competitions and five engaging in activities related to Wushu. Additionally, all participants had studied Chinese history, philosophy, and culture, either independently or through various courses. Furthermore, three participants were actively learning the Chinese language.

## Procedure

After participants agreed to take part, the researcher conducted an initial meeting where they signed written consent, asked questions, and scheduled face-to-face interviews. From October to November 2023, all twelve interviews were held in various cafes, lasting one to two hours each and recorded.

The interview questions explored topics such as Chinese culture and martial arts, focusing on participants' initial interest in Wushu, their experiences and changes over time, their relationships with fellow practitioners, and the impact of training on their self-perception and perceptions of others. Throughout the interviews, the researcher encouraged open dialogue by asking questions and allowing participants to speak freely.

After the interviews, transcripts were reviewed and agreed upon with the participants, with any unwanted details (excluding personal data) removed at their request. Following data analysis, all participants were invited to a debriefing session.

## Ethical considerations

The study design was approved by the director of the Siberian Martial Arts Center and conducted in accordance with the Code of Ethics of the Russian Psychological Society (2006) and the Federal Law of the Russian Federation on Personal Data (2006).

Prior to participating in the study, each participant signed a written consent form, acknowledging their voluntary participation and agreeing to be recorded. They were also informed that they had the right to withdraw from the study at any stage without any negative consequences.

To ensure the confidentiality of the participants, all data collected was anonymized. Any details that could potentially identify individuals were deleted from the transcripts. Additionally, pseudonyms were used for all participants to further protect their identities.

## Data analysis

Thematic analysis was conducted using MAXQDA to extract key themes from the practitioners' narrative interviews. This analysis followed the methodological guidelines established by Braun and Clarke (2006). The initial phase involved generating codes based on

recurring narratives shared by participants, such as their motivations for engaging in Wushu practice. Subsequently, these codes were organized into broader themes; for instance, the theme of "social alienation" emerged from various accounts highlighting the disconnect between Wushu practitioners and those who do not comprehend the significance of their practice.

The final phase involved a rigorous review of the themes to ensure their coherence with the theoretical framework, ultimately identifying connections between the codes and overarching constructs such as "hybrid identity."

To enhance the robustness of the analysis, triangulation was employed through a systematic coding process. This process was collaboratively conducted by the researcher and two research assistants, thereby strengthening intercoder reliability, as supported by Miles and Huberman (1994). Furthermore, communication with participants within the Wushu center allowed for a direct comparison between participants' verbal responses and their actual behaviors observed in the training environment. This comparison was used in conjunction with the findings, which were then discussed with the interviewed participants during debriefing sessions. These discussions facilitated critical reflection on the results and contributed to the validation of the analysis.

## Results

Thematic analysis of the interviews revealed a few interconnected themes.

### Theme 1: the formation of a hybrid identity

The first theme is the development of a new hybrid body image. Participants expressed that they pursued Wushu due to their love for martial arts movies and admiration for iconic figures like Bruce Lee, Jackie Chan, Jet Li, and legendary warriors like Ip Man. They aspired to be like these individuals, which motivated them to train in Wushu. However, while they improved their technical skills, they physically remained white Russian males with well-developed muscles. Nevertheless, mentally, they identified themselves as Wushu practitioners and carriers of Chinese culture, inspired by their role models. They referred to this phenomenon as *judanren* (eggman).<sup>1</sup>

As one participant, S (27 years old, with 2 years of practice), articulated, "On the outside, you are white, but on the inside, you are yellow. Do you understand? I may look like a white guy, but I think like a Chinese master, Shifu." Another participant, M (53 years old, with 20 years of practice), embraced the concept of *judanren*, sharing that his practice has facilitated a profound understanding of Chinese culture, including its mentality, philosophy, and history, which has significantly transformed his worldview.

<sup>1</sup> The term "jūdānrén" (鸡蛋人) originated as a Chinese meme that characterizes foreigners in China who genuinely engage with Chinese culture, symbolizing the duality of being perceived as "white-skinned people with a yellow heart" (Babushkina and Kobayakova, 2017, p. 29). Furthermore, this term has been utilized in media studies (Babushkina and Kobayakova, 2017).



## Theme 2: problems with judanren identity

The hybrid identity of the participants presented several challenges. Firstly, while practicing Wushu, they were expected to uphold its canons and ideals, such as embodying the qualities of a *junzi* (a noble gentleman). As one participant, L (32 years old, with 2 years of practice), explained, “The standards are very different. In the Russian worldview, you need to have big muscles, be macho, and be able to fight anyone. But in Chinese philosophy, it is better to avoid confrontation. Nobody needs big muscles; you should aim for lean and strong muscles, and it’s not about their size. So, in a shirt, I may look like a skinny nerd, but inside, I am a fierce tiger. It’s a joke, but there is some truth in every joke.”

Consequently, these practitioners often felt like outsiders within the sports and fitness community in Russia, even though some continued to practice in the gym or swimming pool alongside Wushu. Additionally, they faced challenges when visiting China for competitions and training, as they were often perceived as *laowais* (foreigners) and experienced a sense of rejection from ordinary citizens, despite some being able to speak Chinese.

## Theme 3: uniform as the elimination of contradictions of hybrid identity

The use of accessories and uniforms is crucial in shaping a new identity for practitioners, serving as an extension of their physical selves and helping to reconcile the contradictions inherent in their hybrid identities. Newcomers may begin their journey wearing simple t-shirts, loose trousers, and their own sneakers or gymnastic slippers. However, consistent practitioners are required to adopt proper attire, including a traditional Chinese Wushu *yifu* uniform and either *Feiyue* or *Budosaga* sneakers. These can be purchased directly at the center or ordered from China. The director of the center emphasizes the importance of the uniform in fostering focus and discipline, noting that it not only organizes individuals but also cultivates a sense of unity among practitioners, regardless of race or nationality.

This shared identity helps mitigate feelings of alienation in various social contexts. Participants highlighted the transformative power of the uniform. For instance, Participant P (40 years old, with 10 years of practice) remarked, “When I’m in casual clothes, I feel like a different person compared to when I’m in uniform. People perceive me differently based on my appearance. For example, they might greet me with a *namaste* gesture, associated with something oriental. The uniform becomes my second skin, distinct from my nationality, skin color, or eye shape.”

The martial arts uniform not only alters how practitioners view themselves but also influences how they are perceived by others. When practitioners wear their uniforms after training, strangers recognize them as Wushu practitioners, transcending national and cultural boundaries. This transformation goes beyond mere physical appearance; it fundamentally shapes the practitioner’s identity and their acknowledgment by others.

Furthermore, the uniform acts as a cultural intermediary, bridging the gap between Russian and Chinese cultures. Participant B (39 years old, with 10 years of practice) explained, “The hybrid identity allows us to build a bridge between Russian and Chinese cultures. After witnessing our performances at fairs or festivals, people approach us

to learn about Chinese culture, knowing that we can provide insights not only as cultural translators but as interpreters. This gives us self-confidence, both individually and as a group of practitioners.”

In summary, the uniform plays a vital role in resolving the contradictions of practitioners’ hybrid identities. It unifies them as a social group, transforms their self-perception, and enables them to act as cultural intermediaries between Russian and Chinese cultures.

## Discussion

The thematic analysis of narrative interviews revealed a cultural hybridity termed *judanren*, referring to individuals who physically present as white Russian males while identifying as Wushu practitioners and custodians of Chinese culture. This bicultural identity departs from traditional studies that primarily focus on immigrants interacting with different cultural groups (Berry, 1980; Bhandari, 2021; Jensen et al., 2011; West et al., 2017). Since Wushu practitioners live within their native environment and represent the dominant culture, their engagement with traditional Chinese culture can be seen as “inner migration,” leading to a unique bicultural identity.

Consequently, the participants in this study assume a bicultural identity, grappling with the tensions between physical appeal and inner self-view. This discord can be resolved through the adoption of a hybrid identity, facilitated by donning a uniform and connecting with like-minded individuals who share an affinity for Chinese traditional culture. As a result, Wushu group members develop a strong collective identity through shared practices and interactions, which reinforce their connection to both Wushu and Chinese culture. This strong sense of group affiliation impacts the formation of participants’ self-concept, as suggested by social identity theory (Tajfel and Turner, 1985).

The emergence of the *judanren* concept emphasizes the complex interplay between cultural influences and body image perceptions, challenging the Western paradigm of body image as a fixed reference (Landor et al., 2024). This highlights the multifaceted nature of body image formation among Wushu male practitioners in this multicultural context, warranting further investigation.

Acknowledging the non-Western paradigm of body image embraced by these individuals provides a comprehensive understanding of their distinct experiences and the influence of cultural factors on body image. This recognition underscores the significance of incorporating diverse cultural perspectives when investigating body image and its intricate relationship with identity.

In conclusion, the analysis of narrative interviews with Wushu male practitioners at the Siberian Chinese Martial Arts Center reveals a nuanced manifestation of cultural hybridity in body image formation. The *judanren* concept is highlighted as illustrating the complex interplay between cultural influences and body image perceptions in a multicultural context.

These findings are seen to extend Social Identity Theory and bicultural identity concepts, particularly in relation to non-Western and hybrid identity formation. Practical implications are offered for instructors in multicultural training environments, emphasizing the necessity of recognizing the diverse cultural backgrounds of their students.

By understanding the unique experiences of these practitioners, the significant role of cultural factors in shaping body image and identity in an increasingly globalized world is appreciated.



## Study limitations

The small sample size limits the generalizability of the findings, as participants were drawn from a single martial arts center in a medium-sized Siberian city. Their experiences may not represent all Wushu practitioners, especially in larger urban areas like Moscow. Future research should include studies in different cities to capture a broader range of experiences and perspectives, considering various genders and cultural contexts.

Additionally, reliance on self-reported data introduces the risk of recall and social desirability biases. To address this limitation, future studies should incorporate observational methods to gain deeper insights into group behaviors and interactions.

Employing mixed-methods approaches can provide a more comprehensive understanding of Wushu practitioners' experiences. Comparative and longitudinal studies can further explore how these experiences vary across cultural contexts and change over time, enhancing the understanding of hybrid identities within the Wushu community.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

Ethical approval was not required for the study involving humans in accordance with the local legislation and institutional requirements. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

ES: Writing – original draft, Methodology, Software. BL: Supervision, Writing – review & editing.

## References

- Babushkina, V. A., and Kobayakova, A. V. (2017). "Sotsikulturnye aspekty ispol'zovaniya memov kak vizual'nyy obraz v kitayskom internet-prostranstve [sociocultural aspects of using memes as a visual image in the Chinese internet space]" in *Drevnie yazyki i sovremennost'*, ed. I. V. Tomasheva (Armavir, Russia: Armavir State Pedagogical University), 29–31.
- Benito-Martinez, V., Lea, J., Lee, F., and Morris, M. W. (2002). Negotiating biculturalism: cultural frame switching in biculturals with oppositional versus compatible cultural identities. *J. Cross-Cult. Psychol.* 33, 492–516. doi: 10.1177/0022022102033005005
- Berry, J. W. (1980). "Acculturation as varieties of adaptation" in *Acculturation: Theory, models, and findings*, ed. A. Padilla (Boulder, CO, US: Westview Press), 9–25.
- Berry, J. W. (1997). Immigration, acculturation, and adaptation. *Appl. Psychol.* 46, 5–34. doi: 10.1111/j.1464-0597.1997.tb01087.x
- Bhandari, N. B. (2021). Diaspora and cultural identity: a conceptual review. *J. Polit. Sci.* 21, 100–108. doi: 10.3126/jps.v21i0.35268
- Braun, V., and Clarke, V. (2006). Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 77–101. doi: 10.1191/1478088706qp0630a
- Bu, B., Haijun, H., Yong, L., Chaohui, Z., Xiaoyuan, Y., and Singh, M. F. (2010). Effects of martial arts on health status: a systematic review. *J. Evid. Based Med.* 3, 205–219. doi: 10.1111/j.1756-5391.2010.01107.x
- Han, Q. S., Theeboom, M., Zhu, D., and Derom, I. (2023). Promoting the Chinese martial arts internationally: is it "kung fu" or "Wushu"? *Int. Rev. Sociol. Sport* 58, 570–588. doi: 10.1177/10126902221117973
- Holmqvist, K., and Frisén, A. (2010). Body dissatisfaction across cultures: Findings and research problems. *European Eating Disorders Review. The Professional Journal of the Eating Disorders Association*, 18, 133–146. doi: 10.1002/erv.965
- Huang, D., and Wang, Y. (2024). Russia's turn to the east: motivating factors. *RUDN J. Polit. Sci.* 26, 18–30. doi: 10.22363/2313-1438-2024-26-1-18-30
- Jennings, G. B. (2010). *Fighters, thinkers and shared cultivation: Experiencing transformation through the long-term practice of traditionalist Chinese martial arts* [doctoral dissertation, University of Exeter]. Available at: [https://ore.exeter.ac.uk/repository/bitstream/handle/10036/116974/JenningsG\\_fm.pdf?sequence=2](https://ore.exeter.ac.uk/repository/bitstream/handle/10036/116974/JenningsG_fm.pdf?sequence=2)
- Jensen, L. A., Arnett, J. J., and MacKenzie, J. (2011). "Globalization and cultural identity" in *Handbook of identity theory and research*, eds S. J. Schwartz, K. Luyckx and V. L. Vignoles (Springer), 285–301.
- Landor, A. M., Winter, V. L., Ramseyer, T., Binitie, I., Chan, J., Craddock, N., et al. (2024). The Sociostructural-intersectional body image (SIBI) framework: understanding

## Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This research was supported by Science Popularization Special Project of the "Shanghai Science and Technology Innovation Action Plan," Grant Number: 23DZ2300600, and the Major Humanities and Social Sciences Project of the Scientific Research and Innovation Program of the Shanghai Municipal Education Commission, Grant Number: 2021-01-07-00-02-E00126.

## Acknowledgments

ES deeply grateful to all the participants who generously shared their time and perspectives for this study, as well as to the Siberian Chinese Martial Art Center for their invaluable support in facilitating the research process. During the preparation of this work, the authors used the You.com service, which employs generative AI technology powered by the GPT-4 model (version 4), developed by OpenAI. Since English isn't the authors' first language, the AI tool was used to check spelling and punctuation. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

the impact of white supremacy in body image research and practice. *Body Image* 48:101674. doi: 10.1016/j.bodyim.2023.101674

Li, W. S., and Dai, G. (2021). The inheritance and dissemination of Wushu culture in the global era. *The International Journal of the History of Sport*, 38, 768–778. doi: 10.1080/09523367.2021.1919093

Matveevskaya, A. S., and Ren, S. (2023). Russian-Chinese cultural ties: challenges and ways to overcome them. *Russia Glob. World* 26, 136–156. doi: 10.48612/rg/RGW.26.4.9

Miles, M. B., and Huberman, A. M. (1994). *Qualitative data analysis: an expanded sourcebook*. Thousand Oaks, CA London, UK, New Delhi, India: Sage.

Moore, B., Dudley, D., and Woodcock, S. (2020). The effect of martial arts training on mental health outcomes: a systematic review and meta-analysis. *J. Bodyw. Mov. Ther.* 24, 402–412. doi: 10.1016/j.jbmt.2020.06.017

Park, C., and Bairner, A. (2023). “Traditional Chinese martial arts: the naming and development of Wushu” in Indigenous, traditional, and folk sports. eds. M. Vaczi and A. Bairner (London, UK: Routledge), 173–183.

Pedriani, L., and Jennings, G. (2021). Cultivating health in martial arts and combat sports pedagogies: a theoretical framework on the care of the self. *Front. Sociol.* 6:601058. doi: 10.3389/fsoc.2021.601058

Rodkiewicz, W. (2014). The turn to the east. The flawed diversification of Russian foreign policy. Marka Karpia: OSW Ośrodek Studiów Wschodnich im.

Tajfel, H., and Turner, J. C. (1985). “The social identity theory of intergroup behavior” in *Psychology of intergroup relations*. eds. S. Worchel and W. Austin (Chicago, IL, USA: Nelson-Hall), 7–24.

Theeboom, M., and De Knop, P. (1997). An analysis of the development of Wushu. *Int. Rev. Sociol. Sport* 32, 267–282. doi: 10.1177/1012690297032003004

Tzeng, C. C., Tan, T. C., and Bairner, A. (2023). Responder or promoter? Investigating the role of nation-state in globalization: the case of China's strategies in the global Wushu movement. *Int. Rev. Sociol. Sport* 58, 308–327. doi: 10.1177/10126902221096947

Wąsik, J., and Wójcik, A. (2017). Health in the context of martial arts practice. *Phys. Act. Rev.* 5, 91–94. doi: 10.16926/par.2017.05.13

West, A. L., Zhang, R., Yampolsky, M., and Sasaki, J. Y. (2017). More than the sum of its parts: a transformative theory of biculturalism. *J. Cross-Cult. Psychol.* 48, 963–990. doi: 10.1177/0022022117709533

Xue, C., Bai, H., Niu, Y., and Zhang, R. (2023). The role of Wushu martial arts representation in the contemporary mass culture of the world. *Crit. Arts* 37, 45–61. doi: 10.1080/02560046.2023.2255637

Zhou, L. (2021). Mesto kitayskikh dram v rossiyskom sotsikul'turnom prostranstve [the place of Chinese dramas in the Russian sociocultural space]. *Galactica Media* 4, 91–108. doi: 10.46539/gmd.v3i4.234



## OPEN ACCESS

## EDITED BY

Leonardo Vidal Andreato,  
University of the State of Amazonas, Brazil

## REVIEWED BY

Braulio Henrique Magnani Branco,  
University Center of Maringá (UniCesumar),  
Brazil  
Donizete Oliveira,  
Universidade Federal do Triângulo Mineiro,  
Brazil

## \*CORRESPONDENCE

K. A. Steel  
✉ k.steel@westernsydney.edu.au

RECEIVED 21 July 2024

ACCEPTED 18 November 2024

PUBLISHED 02 December 2024

## CITATION

Incognito MR, Watson T, Weidemann G and  
Steel KA (2024) The role of the opponent's  
head in perception of kick target location in  
martial arts.  
Front. Sports Act. Living 6:1468209.  
doi: 10.3389/fspor.2024.1468209

## COPYRIGHT

© 2024 Incognito, Watson, Weidemann G and  
Steel. This is an open-access article distributed  
under the terms of the [Creative Commons  
Attribution License \(CC BY\)](#). The use,  
distribution or reproduction in other forums is  
permitted, provided the original author(s) and  
the copyright owner(s) are credited and that  
the original publication in this journal is cited,  
in accordance with accepted academic  
practice. No use, distribution or reproduction  
is permitted which does not comply with  
these terms.

# The role of the opponent's head in perception of kick target location in martial arts

M. R. Incognito<sup>1</sup>, T. Watson<sup>2,3</sup>, G. Weidemann<sup>1,3,4</sup> and K. A. Steel<sup>3,4,5\*</sup>

<sup>1</sup>School of Psychology, Western Sydney University, Sydney, NSW, Australia, <sup>2</sup>School of Social Sciences, Western Sydney University, Sydney, NSW, Australia, <sup>3</sup>MARCS Institute, Western Sydney University, Sydney, NSW, Australia, <sup>4</sup>THRI, Western Sydney University, Sydney, NSW, Australia, <sup>5</sup>School of Health Sciences, Western Sydney University, Sydney, NSW, Australia

Athletes in Martial Arts must anticipate the target of their opponent's kick or strike to avoid contact. Findings suggest that features, e.g., head and face may play a greater role in predicting opponent action intent compared to global movement information, however little research has explored the role of the head in action anticipation. The aim of this study was to examine the role of the head in predicting the target of a kicking action in martial arts.  $N = 76$  volunteer participants ( $n = 32$  athletes  $> 5$  years of experience,  $n = 36$  non-athletes with no experience) were asked to watch a series of video clips depicting various kicking techniques with differing levels of spatial occlusion of the head. These clips were also temporally occluded compelling participants to predict the landing target of each kick (i.e., head or chest). The hypothesis of the current study is that athletes would be more accurate than non-athletes, but there was no significant effect of expertise on accuracy. Both athletes and non-athletes performed well above chance level performance. Head occlusion did not significantly influence performance and did not interact with expertise, suggesting head and face information did not play a role in predicting opponent action intent. Across participants the landing target of the roundhouse kick was identified with greater accuracy than the front or the back kick. Additionally, participants identified kicks from the rear leg with greater accuracy than the front leg. These findings have significant implications for combat sports where athletes are required to anticipate the action intent of their opponent to formulate an effective defensive response.

## KEYWORDS

accuracy, kick, expertise, face, head, intention, perception

## Introduction

Combat sports are dynamic and fast paced, requiring athletes to predict the movement intentions of their opponent based on body movement cues. Fighting stance, head movement and pace of movement are just some of the visual cues athletes use to anticipate their opponent's next attack and inform an appropriate defensive response. Elite performance in fighting sports of Martial Arts (e.g., King Fu, Karate, Judo, Jiu-jitsu) is dependent on an athlete's perceptual performance, particularly given the constraints presented by the size of the competition space which forces fighters to always remain close to one another (1).

Perceptual-motor expertise gained through task-specific training and effective practice enhances perceptual performance on similar tasks (2, 3). Biological motion research

broadly explores the mechanisms underlying perceptual-motor expertise and the contexts where skilled perceptual ability can elicit ideal responses and improve performance (4). This is most relevant to the current study which examines the perceptual capacity of individuals to use biological motion cues to predict attack location in a competitive sporting context.

Research demonstrates that humans can extract internal state and intention information such as fear, emotional states, gender, sexual orientation, and deceit (5–10) from human movement, at above chance levels, depending on the tasks and type of visual display. Techniques that occlude or manipulate movement information and examine the impact this has on perceptual performance, identify the value of certain biological motion cues (11). For example, spatial occlusion of the trunk and attacking arm hindered expert fencers, suggesting they rely on these cues for perceptual performance (12). However, occluding various parts of the body had no impact on perceptual performance amongst Taekwondo athletes, suggesting biological motion perception has the potential to be maintained even when part of the stimulus is visually obstructed (13). This suggests that individuals with perceptual-motor expertise may have developed the capacity to use specific cues learned through experience. That is, they do not need to perceive all details of the stimulus to excel in perceptual performance (14–16).

Disparities in perceptual performance have been found between athlete and novice groups across a variety of ball sports (17–20), indicating that athletes demonstrate a heightened level of perceptual performance by utilizing kinematic cues (21–23). This ability is essential in combat sports such as Martial Arts, where athletes must recognize offensive movements and formulate an appropriate defensive response with speed and accuracy (11). Across a range of combat sports extensive task specific perceptual-motor practice allows Martial Artists to accurately anticipate future movements based on kinematic cues (11, 12, 24–29). However, reaction time findings have yielded mixed results, indicating that athletes perform slower than non-athletes on perceptual tasks (30, 31) or the same (32–35).

Another consideration is the visual strategies used by martial artists to increase intent accuracy of an opponent. This generally consists of individuals scanning along the vertical axis of their opponent's body, shifting their visual gaze between the head and trunk, thus allowing accurate anticipation of future movement. This visual strategy, in which visual gaze is fixed on the most central features of the body, allows for the detection of kinematic changes more efficiently using peripheral vision, thus producing a superior level of perceptual performance (11). Conversely, novices tend to fixate their gaze on the peripheral features such as the upper and lower limbs (12, 24, 26, 28, 36). Therefore, the visual focus combat athletes place on their opponent's chest and head area would seem to play a key role in their performance success. Despite this research, it is unclear what specific information athletes extract from the upper body to guide their performance in combat sports.

The role the head and chest play in guiding perceptual performance is a matter of ongoing debate. The head is the most central and stable part of the body in combat sports and can

serve as a fixation point, allowing for efficient use of both central and peripheral vision in detecting movement (37, 38). However, it is possible that facial information provides anticipatory cues given the important survival functions they play in conveying social information related to emotion and intention (39, 40). Facial expressions are perceived in the same automatic manner as movement (41, 42) and have been shown to play a role in accurately predicting sporting outcomes in baseball (43) and Taekwondo (44). However, Prigent et al. (45) examined this effect in basketball and found that facial expressions were used in effort-judgements but not in action-anticipation, with a larger emphasis placed on body movement for predicting the landing location of thrown balls. It is possible that athletes may question their truthfulness in providing accurate anticipatory cues due to the ability to manipulate facial expressions to hide information (46).

In combat sports, anticipatory cues may be extracted from several sources including redistribution of weight, and elevation of centre of mass (2), knee (47), and punch or kick (48). Facial expressions may also aid perceptual performance (49), yet only one study has examined the face and head as a source of perceptual information previously. In the Martial Arts discipline of Petri et al. (23) found that facial information had no effect on perceptual performance, indicating they provide no useful anticipatory cues. Furthermore, the authors suggest that the removal of facial information encouraged athletes to attend to other, more relevant kinematic cues including the head and trunk. Consistent with this, reaction time increased in the presence of facial expressions, potentially due to the additional time required to process facial expressions. However, research specific to combat sports remains limited with no research examining whether perceptual-motor expertise influences the extent to which facial information or other kinematic cues are used to anticipate attack intent.

The purpose of the current study was to examine what visual information Martial Artists and novices utilize during perceptual performance based current research evidence related to the visual cues attained from the head and face and used in movement anticipation. Specifically, we aimed to examine whether the role of the head and face role is limited to a fixation point or whether facial information provides important anticipatory cues used to predict movement outcomes. In line with previous findings, we hypothesized that athletes would make more accurate predictions, and with shorter reaction times than novices across all conditions of spatial occlusion. Additionally, we hypothesized that athlete performance would be hindered by the presence of facial expressions but impeded by the complete removal of the head. We expected to find no differences among non-athletes across spatial occlusion conditions.

## Methods

### Participants

Thirty-three active Martial Arts athletes (males = 20, females = 13; mean<sub>age</sub> = 34.4 ± 15.6, range<sub>age</sub> = 18–71) with more than 5 years of experience, forty-four non-athletes (males = 9, females = 34,

other = 1;  $\text{mean}_{\text{age}} = 23.5 \pm 6.4$ ,  $\text{range}_{\text{age}} = 18\text{--}51$ ) with no martial arts experience volunteered to participate in this study and provided a complete data set. Participants in the athlete group had at least 5 years of training experience ( $\text{mean years of training} = 15.7 \pm 8.7$ ) across a range of styles of Martial Arts including Karate, Taekwondo, Kickboxing, Mixed Martial Arts, Muay Thai, and Kung Fu. Non-athletes were recruited from first year psychology students via an online recruitment system and received course credit for participation. Eighty-eight participants provided informed consent in accordance with the ethical procedures approved by the University Human Ethics Committee and completed the online task, but eleven athletes were excluded as they had less 5 years martial arts experience, and a further nine participants (one athlete and eight non-athletes) were excluded due to high levels (>30%) of responses prior to stimulus presentation, indicating that they were not performing the task as instructed [Approval number: H14383].

## Materials

A spatial occlusion technique was used to manipulate head and face visibility and directly compare the effect this would have on perceptual performance between athletes and non-athletes. Specifically, a video-based task was built and hosted using the online data collection platform Gorilla.sc, and participants were instructed to complete the task on any laptop or desktop computer with a minimum screen size of 14 inches. The video-stimuli used in the task displayed a senior female Martial Artist demonstrating one of three fundamental kicking techniques (front kick, roundhouse kick, back kick) from the first-person

perspective, using either the front or rear leg and aimed at either head or chest level. Each stimulus clip began with a freeze frame lasting 3,000 ms, followed by initiation of the technique. The clip was occluded just prior to its completion so the landing location was not visible. Additionally, visibility of the athlete's head and facial expressions were manipulated using the Adobe Premier PRO (version 9.0.0, Adobe Systems). The face was either unmanipulated (C1), blurred (C2) or the head was erased completely (C3) (Figure 1).

## Procedure

The session began with participants completing a short questionnaire that gathered data on age, gender, and level of martial arts experience, which was followed by the video-based task. Prior to commencing the video-based task, participants were told that they would observe a randomized series of clips which depicted a martial artist performing a variety of kicking techniques. After viewing each clip participants were required to indicate whether they anticipated that the athlete's kick was aimed at a hypothetical opponent's chest by pressing the "c" key, or at the head by pressing the "h" key of the computer keyboard. Participants were also given a practice trial prior to starting the test sequence to ensure they were familiar and comfortable with the task requirements. Each video-stimulus was presented at all levels of manipulation twice; 3 head cue manipulations  $\times$  3 kick types  $\times$  2 kick landing locations  $\times$  2 legs  $\times$  2 repetitions. The seventy-two trials were presented in randomized order to avoid predictability. The outcome variables were proportion of correct responses (Accuracy) and time taken to respond on correct



FIGURE 1

Head and face visibility manipulation. Spatial occlusion conditions. C1 (condition 1): normal; C2 (condition 2): face blurred; C3 (condition 3): head removed.



response (Reaction Time) after the start of the video playback. Any responses made prior to 3,000 ms were made before the onset of biological motion.

## Results

Of the participants who provided a complete data set ( $n = 88$ ), nine participants were excluded from the final analysis as more than 30% of their responses were less than 3,500 ms, indicating that they did not complete the task as instructed leaving ( $n = 79$ ). Thirty-two participants were athletes (>5 years' experience), 36 novices (no experience), and eleven had martial arts experience but less than 5-years' experience. Analysis of athletes and non-athletes was conducted on the data of 68 participants.

To analyze the data, we created a linear mixed-effects model of accuracy and reaction time data in RStudio (version 2023.12.0) using the Lme4 package. We used the linear mixed effects model to analyze the data in preference to an ANOVA due to the complex within- and between-subject nature of the experimental design. The linear mixed effects model is better able to estimate the variance due to subject and condition and to account for any correlated errors in the data, leading to a more accurate estimate of error. The linear mixed effects models included participant group (athlete and non-athlete), head visibility condition (visible, head blurred, head absent), kick type (front, roundhouse, back), kick landing location (head, chest) and leg (front, rear) as fixed effects. A random intercept was included for participants, and random slopes for kick type, kick landing location and leg for the model of accuracy, as this was determined to be the optimal fit. A random intercept for participants, but no random slopes for the other factors, was included in the model of correct reaction-times, as the more complex model did not converge. The effect size of the predictor variable on the outcome variable was assessed using Cohen's  $f^2$ , by comparing the full model and the reduced model with the predictor variable removed. Satterthwaite's method was used to determine degrees of freedom and significance of fixed effects and interactions (50) using the afex package. Simulations using this method of significance estimation produced acceptable Type I error rates for small samples (51). As there is no simple way to assess power with a linear mixed effects model, Monte Carlo simulations with the model used have been suggested as the most appropriate way to estimate power. Consequently, we ran simulations using the linear mixed effects model of accuracy with the SIMR package. These simulations showed that there was 76% power to detect a fixed effect of group of 0.2 using the linear mixed effects model employed for accuracy.

Contrary to our hypothesis, athletes (mean = 0.68, sd = 0.10) in our sample were not more accurate than non-athletes (mean = 0.66, sd = 0.09) in determining the target location of the kick, as evidenced by the absence of a main effect of athlete grouping on accuracy,  $F < 1$  (Figure 2a). Nonetheless, both athlete and non-athlete participants were above chance in correctly determining the target location [ $t_{(31)} = 9.85$ ,  $p < 0.001$ ;  $t_{(35)} = 11.46$ ,  $p < 0.001$ , respectively]. Also, contrary to our hypotheses, there was no evidence that athletes (mean = 4,215, sd = 409) were significantly

faster than non-athletes (mean = 4,342, sd = 409) in making correct judgements about the target location, with the main effect of athlete grouping failing to reach the declared level of significance,  $F_{(1, 67)} = 1.38$ ,  $p = 0.24$  (Figure 2b). Due to the differences in gender balance between the athlete and non-athlete participants we assessed whether there was any evidence of effect of gender on accuracy or reactions times. There is no evidence in the data from the current study of a significant difference in accuracy between male and female participants (male accuracy = 0.686, female accuracy = 0.659, Welch two sample  $t_{(45,31)} = 1.103$ ,  $p = 0.2757$ , 95% CI = (-0.076 0.022); or of a significant difference in reaction time [male RT = 4,252.284, female RT = 4,305.652, Welch two sample  $t_{(57,42)} = 0.525$ ,  $p = 0.601$ ].

Spatial occlusion did not significantly influence target location accuracy (C1 mean = 0.68, sd = 0.11, C2 mean = 0.66, sd = 0.11, and C3 = 0.66, sd = 0.11) when assessed across all participants,  $F_{(2, 4,492)} = 1.145$ ,  $p = 0.32$  (Figure 2c). Furthermore, contrary to our hypotheses, there was no evidence of an interaction between athlete grouping and spatial occlusion on accuracy,  $F < 1$ . Similarly, across all participants, there was no evidence of differences in correct reaction times as a function of spatial occlusion (C1 mean = 4,229, sd = 374, C2 mean = 4,299, sd = 410, C3 mean = 4,311, sd = 577)  $F_{(2, 3,099)} = 1.463$ ,  $p = 0.23$  (Figure 2d), and there was no evidence of an interaction between athlete grouping and spatial occlusion,  $F < 1$ . However, this result is consistent with the prediction that there would be no differences across spatial occlusion conditions among non-athletes.

Across both athlete and non-athlete participants there were differences in accuracy and correct reaction times for the different kick types, and as a function of which leg was used to perform the kick. Figure 3 shows both accuracy and correct reaction times for the various kick types and for the forward and rear leg. From this figure it is apparent that participants were more accurate in assessing the target location of the kick for the roundhouse (mean = 0.75, sd = 0.15), than for the back (mean = 0.66, sd = 0.13), and the least accurate for the front kick (mean = 0.60, sd = 0.11), evidenced by a main effect of kick type,  $F_{(2, 38)} = 38.59$ ,  $p < 0.001$ , Cohen's  $f^2 = 0.21$ , there was no evidence that this comparison interacted with athlete grouping  $F < 1$ . Pairwise comparisons between the three different kick types confirmed that accuracy was greater for roundhouse than for front [ $t_{(67)} = 7.52$ ,  $p < 0.001$ ] and for back [ $t_{(67)} = 5.20$ ,  $p < 0.001$ ], and that accuracy for the back was greater than for the front kick [ $t_{(67)} = 3.41$ ,  $p = 0.001$ ]. Reaction times were faster for the roundhouse (mean = 4,261, sd = 615) and the front kick (mean = 4,119, sd = 386) than the back kick (mean = 4,471, sd = 407), which was confirmed by a main effect of kick type,  $F_{(2,3,108)} = 26.19$ ,  $p < 0.001$ , Cohen's  $f^2 = 0.03$ , the interaction between kick type and athlete grouping approached but failed to reach the declared level of significance,  $F_{(2,3,108)} = 2.50$ ,  $p = 0.08$ . Pairwise comparisons between the three different kick types confirmed that responding was slower for the back than the front [ $t_{(67)} = 10.88$ ,  $p < 0.001$ ] and for the roundhouse kick [ $t_{(67)} = 5.003$ ,  $p < 0.001$ ] but there was no evidence for a significant difference for the front and roundhouse kicks when controlling for multiple comparisons [ $t_{(67)} = 2.11$ ,  $p = 0.038$ ]. From Figure 3 it is also apparent that participants were

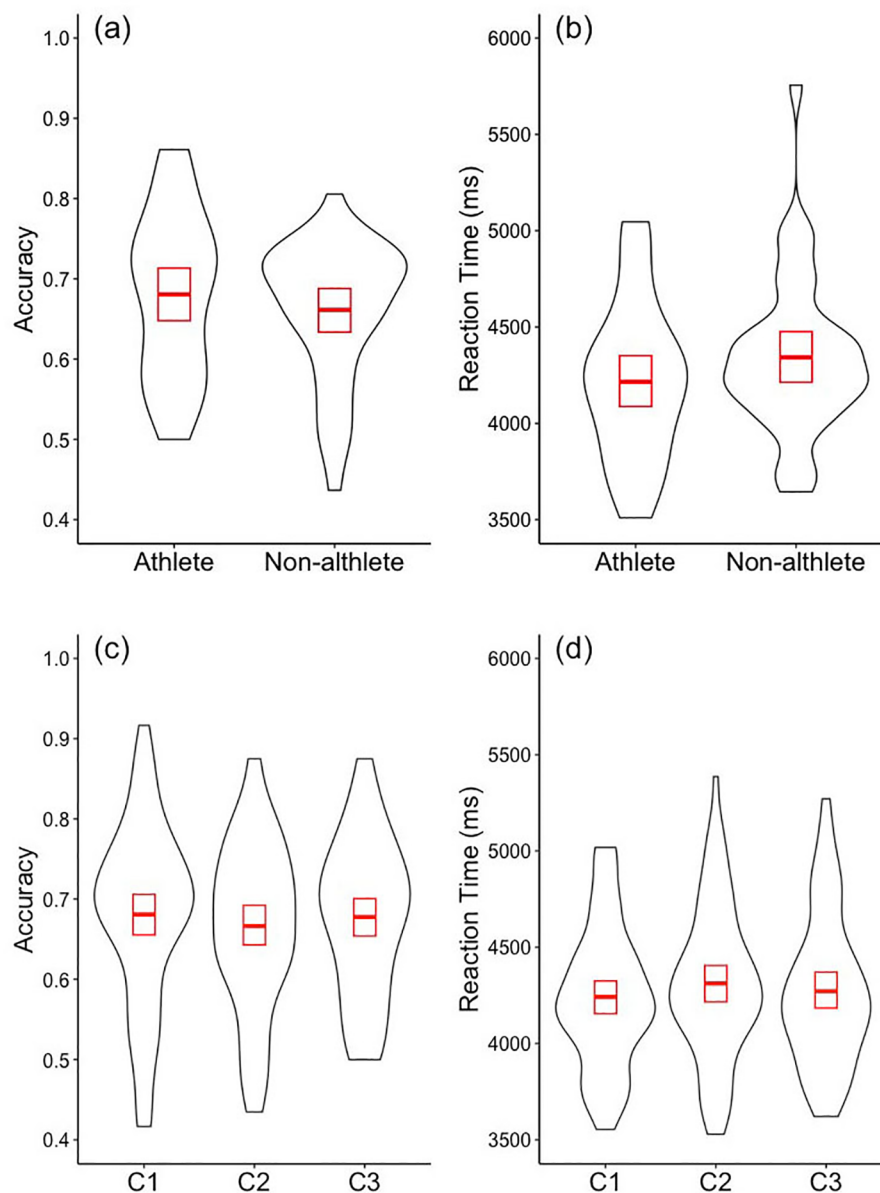


FIGURE 2

Athlete and non-athlete performance and performance across conditions. Violin plots of the accuracy (a,c) and the correct reaction times (b,d) of the athlete and the non-athlete participants (a,b) and across the three visibility conditions (c,d) in determining the target location of the kick. The red rectangles show the 95% confidence intervals, and the red middle line shows the group mean.

more accurate in assessing the target location of the rear leg (mean = 0.72, sd = 0.13) than the front leg kicks (mean = 0.62, sd = 0.08), which was confirmed by a main effect of leg position  $F_{(1,67.5)} = 47.39$ ,  $p < 0.001$ , Cohen's  $f^2 = 0.07$ , there was no evidence that this interacted with athlete grouping,  $F < 1$ . The greater accuracy for the rear leg kicks is associated with a slower reaction time (Rear mean = 4,358, sd = 503, Forward mean = 4,195, sd = 393) which was also confirmed by a main effect of leg position,  $F_{(1,3,106)} = 16.04$ ,  $p < 0.001$ , Cohen's  $f^2 = 0.02$ , but there was no evidence for an interaction with athlete grouping,  $F < 1$ .

## Discussion

The purpose of this study was to examine the role of the head of an opposing individual when predicting the action intent of kicking techniques in Martial Arts. We hypothesized that athletes would predict the landing location of kicks at different levels of spatial occlusion faster and more accurately than novices. However, data analysis indicates that athletes were no more accurate and did not exhibit faster reaction times than novices, indicating there was no effect of expertise on predicting action intent. This is contrary to movement perception findings

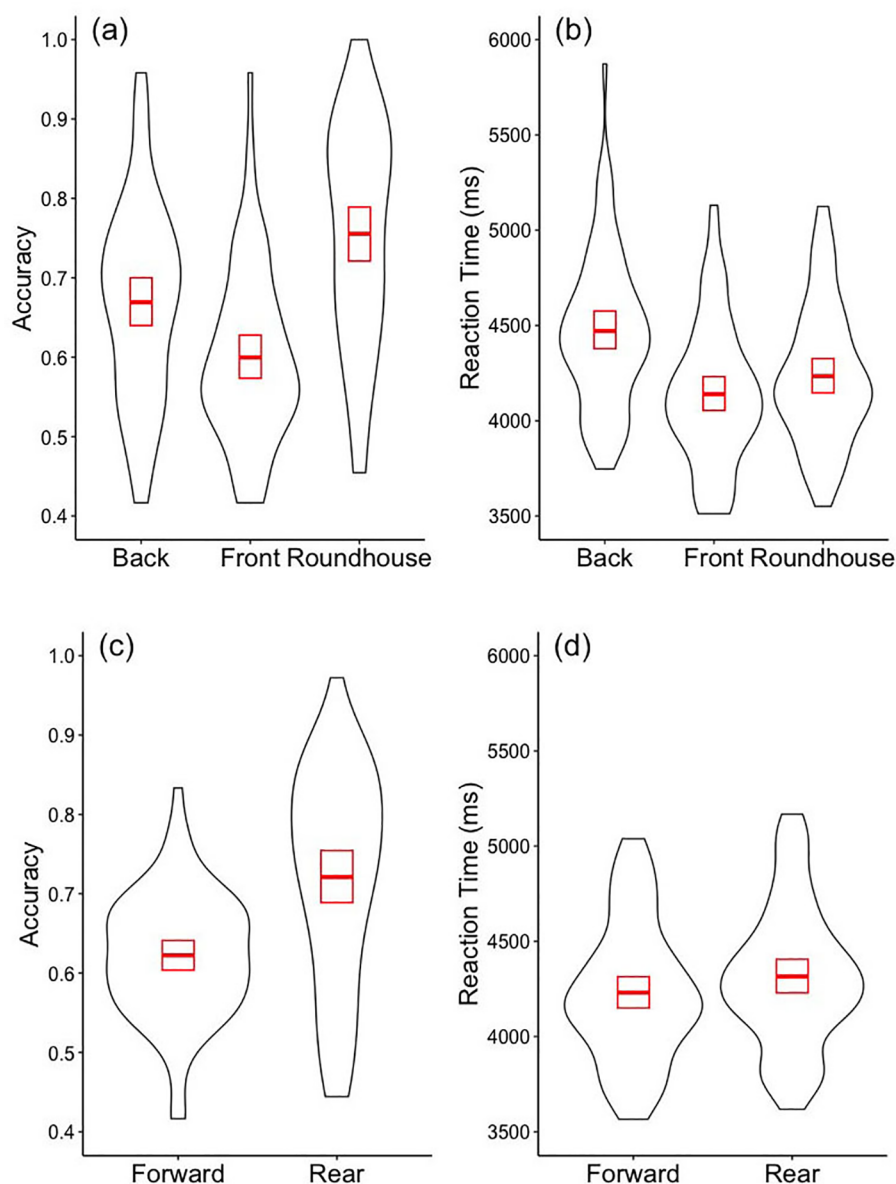


FIGURE 3

Performance for different kick types and Leg. Violin plots of the accuracy (a,c) and the correct reaction times (b,d), across all participants in determining the target location, for the Back, Front and Roundhouse kick types (a,b) and for the Forward and Rear leg (c,d). The red rectangles show the 95% confidence intervals, and the red middle line shows the mean for each condition.

which indicate an effect of expertise on action intent accuracy in the sporting field especially balls sports (17–20, 52, 53), and more specifically in the field of combat sports (11, 12, 24–29). We note that there were differences in the gender balance between the athlete and non-athlete groups but there was no evidence that participant gender influenced accuracy or reaction times. Our findings contribute to the mixed results found when exploring the effect of expertise on reaction time in combat sports (30, 32–35, 54–57).

Data analysis showed no significant differences in reaction time or accuracy of action intent estimation between participants across different levels of spatial occlusion of the head. This suggests that

head information and more specifically facial information may not always play a critical role in intention prediction in combat sports. This is contrary neurophysiological research using preferential looking paradigms which demonstrates an attentional bias to the human body and face, that emerges early in development and suggests that biological motion perception is hardwired (58, 59). Moreover, some research examining eye movement in combat sports shows that a large visual focus is placed on the head of an athlete's opponent. It is unclear however, whether this is for the purpose of gaze stabilisation (37) or because useful information can be extracted from facial expressions or gaze (49). Because there was no effect of spatial

occlusion on perceptual performance, this indicates that kinematic information is extracted from global body information rather than from the head. This aligns with early point-light studies in which masking of body form had no effect on an individual's ability to recognize biological motion (14, 16, 60–62), and where perceptual-motor expertise did not play a role in the global processing of information. Like our findings, research has shown that individuals do not need to perceive all details of a stimulus to perceive action intent, therefore suggesting a global approach to processing of kinematic information (14–16, 23).

Our findings also challenge the idea that perceptual-motor expertise improves an individual's ability to perceive task-specific action intent, with expertise not having a statistically significant effect on accuracy or reaction times. This may be attributed to the study design where we tested recognition, rather than response selection and execution. It is feasible that prioritization of and an ability to recognize biological motion intent is innate, with refinement development from a young age due to the importance socially and for survival (63–65), while perceptual-motor expertise is acquired with experience and used for response selection and execution. For example, Kuhlmeier et al. (63) found that the ability to distinguish non-biological motion from biological motion was already present for 6-month-old infants. This is corroborated by Simion et al. (64) who demonstrated the ability of 6-month-olds to distinguish biological motion attributes including the direction a stimulus moves. Yet the recognition of biological agents does not translate to being able to walk. Infants must first develop muscular strength and neural coordination to maintain head stability, sitting posture and eventually standing posture, only then can they perform skills that they recognize in others (66). This may remain true for adults perceiving biological motion in combat sport contexts whereby the task to identify or recognize threat is hardwired but this does not equate to accurate selection and execution of response. Consequently, future research could examine the differences between athletes and novices in action-response performance.

Different kick types provide differentially salient movement cues that can be used for the prediction of action intent. And while not the intent of this study an unexpected finding arose regarding the effect of kick type and kicking leg on perceptual performance. Data analysis showed that participants could identify the target of a roundhouse kick with greater accuracy than a front or back kick. Like the front kick, the roundhouse kick involves a motion whereby the kicker must lift their knee towards the landing location before extending the leg. Because the kick takes the shape of an arc, the knee must be lifted in a rounded motion, instead of a straight upward motion like that used for the front kick. The roundhouse kick is also a forward-facing kick meaning it is simpler than the back kick, which involves a backwards turning motion that may aid in concealment of useful kinematic cues which predict landing location. It is possible that the redistribution of weight and change in elevation of centre of mass (2) may account for this ability. Alternatively, as the roundhouse kick takes longer to execute (approx. 260 ms) compared to a punch (200 ms) (24), it

affords more time to accurately interpret cues (67), or if a rounded motion is just inherently easier to recognize than a straight upward motion (or both).

Speed is not the only important variable when considering the effectiveness of kick types. In fact, a power-speed trade-off may also occur for different kick types. In Martial Arts, variables such as tempo (speed), as well as rotation of the hips are manipulated in the ring so that an athlete can throw kicking techniques at different levels of speed and power to confuse their opponent, thus decreasing predictability (68). For example, the roundhouse kick is typically used in combat sports as a “power kick” (or a “finisher”), and therefore it may be the case that speed is sacrificed to generate enough force for the kick's intended purpose.

Participants in this study, regardless of expertise, also demonstrated greater intent accuracy when the kick originated with the rear leg compared to the front leg. This may be because the rear leg is further away, and hence takes more time to perform a kicking technique, whereas the front leg is closer to the opponent, taking a shorter amount of time to land. Again, it is possible the speed-power tradeoff is at play here, with kicks on the rear leg typically being power kicks. With the roundhouse kick for example, because the leg has further to travel, the athlete has more room to turn their hips and generate a larger amount of force behind the kick. Whereas the athlete has less range of motion to turn their hips and generate power on the front leg as this is closer to their opponent.

This study is the first to have directly investigated whether the head or face is used in action anticipation in combat sports, calling for further investigation using methodologies which produce more generalizable findings. However, we acknowledge that subsequent studies should include other body segments such as trunk/chest. Overall, however these findings have significant implications for combat sports where athletes must anticipate the movement intentions of their opponent and formulate an appropriate defensive response before the movement is completed. This provides real-world implications in terms of informed evidence-based training interventions in combat sports. The increased salience of certain types of kicks delivered on specific legs can inform training practices and fight strategy to help fighters gain an advantage by utilizing techniques that are hardest to identify and respond to. In addition, this knowledge can inform training programs used to enhance the safety of individuals across many lines of work including police officers, paramedics, security guards and defence personnel, in terms of teaching physical self-defense techniques that are difficult to identify and therefore increase their safety.

The findings also align with global processing of information which posits that biological motion is perceived at a global level and can be maintained even when the stimulus is visually occluded. Because there were no differences in performance between groups this suggests global processing is not dependent on perceptual-motor expertise. However, further research is needed to establish what then separates experts from novices, as it may not necessarily be recognition of movement but what follows, e.g., response selection and execution. Further research may also be needed to establish how we can increase our ability

to identify less salient kicks of certain legs, which could then inform interventions aimed at improving movement perception. Lastly, future research should incorporate a broader range of skill-based stimuli, including strikes, punches, and diverse kicking techniques from various martial arts disciplines. This approach will not only diversify the stimulus set and contribute to advancing knowledge and techniques but also facilitate the use of match-based stimuli, thereby enhancing ecological validity by replicating more realistic competitive environments.

## Conclusion

The goal of this research was to investigate the practical applications of the perception of biological motions cues to sports performance, specifically, the role of the head when determining action intention associated with different kick types commonly used in martial arts. The results of this study indicated that head occlusion did not significantly influence performance or interact with expertise. This suggests head and face information did not play a role in predicting opponent action intent. Moreover, across participants the landing target of the roundhouse kick was identified with greater accuracy than the front or the back kick. The difference in accuracy between kick types is likely a result of the increased exposure time afforded by a roundhouse kick. These findings suggest that attention to head and face in Martial Arts does not enhance intent estimation and therefore should not be a significant focus during training sessions.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by Western Sydney University Human Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written

informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

## Author contributions

MI: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. TW: Conceptualization, Formal Analysis, Investigation, Methodology, Resources, Supervision, Software, Writing – original draft, Writing – review & editing. GW: Conceptualization, Formal Analysis, Investigation, Methodology, Resources, Supervision, Writing – original draft, Writing – review & editing. KS: Conceptualization, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Chen WY, Wu SK, Song TF, Chou KM, Wang KY, Chang YC, et al. Perceptual and motor performance of combat-sport athletes differs according to specific demands of the discipline. *Percept Mot Skills*. (2017) 124(1):293–313. doi: 10.1177/0031512516681342
- Hoelbling D, Smiech MM, Cizmic D, Baca A, Dabnichki P. Exploration of martial arts kick initiation actions and telegraphs. *Int J Perform Anal Sport*. (2021) 21(4):507–18. doi: 10.1080/24748668.2021.1920314
- Steel K, Ellem E, Baxter D. The application of biological motion research: biometrics, sport, and the military. *Psychon Bull Rev*. (2015) 22(1):78–87. doi: 10.3758/s13423-014-0659-5
- Brenton J, Müller S. Is visual-perceptual or motor expertise critical for expert anticipation in sport? *Appl Cogn Psychol*. (2018) 32(6):739–46. doi: 10.1002/acp.3453
- Diaz GJ, Fajen BR, Phillips F. Anticipation from biological motion: the goalkeeper problem. *J Exp Psychol Hum Percept Perform*. (2012) 38(4):848. doi: 10.1037/a0026962
- Grèzes J, Frith C, Passingham RE. Brain mechanisms for inferring deceit in the actions of others. *J Neurosci*. (2004) 24(24):5500–5. doi: 10.1523/JNEUROSCI.0219-04.2004
- Johnson KL, Gill S, Reichman V, Tassinari LG. Swagger, sway, and sexuality: judging sexual orientation from body motion and morphology. *J Pers Soc Psychol*. (2007) 93(3):321–34. doi: 10.1037/0022-3514.93.3.321



8. Pollick FE, Kay JW, Heim K, Stringer R. Gender recognition from point-light walkers. *J Exp Psychol Hum Percept Perform.* (2005) 31(6):1247–65. doi: 10.1037/0096-1523.31.6.1247
9. Pavlova MA. Biological motion processing as a hallmark of social cognition. *Cereb Cortex.* (2012) 22(5):981–95. doi: 10.1093/cercor/bhr156
10. Stienen BMC, de Gelder B. Fear detection and visual awareness in perceiving bodily expressions. *Emotion.* (2011) 11(5):1182–9. doi: 10.1037/a0024032
11. Martínez del Quel Ó, Bennett SJ. Perceptual-cognitive expertise in combat sports: a narrative review and a model of perception-action. *Rev Int Cienc Deporte.* (2019) 58(15):323–38. doi: 10.5232/ricyde2019.05802
12. Hagemann N, Schorer J, Canal-Bruland R, Lotz S, Strauss B. Visual perception in fencing: do the eye movements of fencers represent their information pickup? *Atten Percept Psychophys.* (2010) 72(8):2204–14. doi: 10.3758/BF03196695
13. Torrontegui Ronco E, Martínez de Quel Pérez Ó, López Adán E. El uso de la información visual en situaciones de limitación temporal en deportistas de élite de taekwondo. *Kronos.* (2013) 12:30–9.
14. Bertenthal BI, Pinto J. Global processing of biological motions. *Psychol Sci.* (1994) 5(4):221–5. doi: 10.1111/j.1467-9280.1994.tb00504.x
15. Huys R, Cañal-Bruland R, Hagemann N, Beek PJ, Smeeton NJ, Williams AM. Global information pickup underpins anticipation of tennis shot direction. *J Mot Behav.* (2009) 41(2):158–71. doi: 10.3200/JMBR.41.2.158-171
16. Thornton IM, Pinto J, Shiffrar M. The visual perception of human locomotion. *Cogn Neuropsychol.* (1998) 15:535–52. doi: 10.1080/026432998381014
17. Abernethy B. Anticipation in squash: differences in advance cue utilization between expert and novice players. *J Sports Sci.* (1990) 8(1):17–34. doi: 10.1080/02640419008732128
18. Roca A, Ford P, McRobert A, Mark Williams A. Identifying the processes underpinning anticipation and decision-making in a dynamic time-constrained task. *Cogn Process.* (2011) 12(3):301–10. doi: 10.1007/s10339-011-0392-1
19. Urgesi C, Savonitto MM, Fabbro F, Aglioti SM. Long- and short-term plastic modelling of action prediction abilities in volleyball. *Psychol Res.* (2012) 76(4):542–60. doi: 10.1007/s00426-011-0383-y
20. Wu Y, Zeng Y, Zhang L, Wang S, Wang D, Tan X, et al. The role of visual perception in action anticipation in basketball athletes. *Neuroscience.* (2013) 237:29–41. doi: 10.1016/j.neuroscience.2013.01.048
21. Ottonboni G, Russo G, Tessari A. What boxing-related stimuli reveal about response behavior. *J Sports Sci.* (2015) 33(10):1019–27. doi: 10.1080/02640414.2014.977939
22. Russo G, Ottonboni G. The perceptual-cognitive skills of combat sports athletes: a systematic review. *Psychol Sport Exerc.* (2019) 44:60–78. doi: 10.1016/j.psychsport.2019.05.004
23. Petri K, Bandow N, Salb S, Witte K. The influence of facial expressions on attack recognition and response behaviour in karate kumite. *Eur J Sport Sci.* (2018) 19(4):529–38. doi: 10.1080/17461391.2018.1536170
24. Lee J, Kim S, Song Y. Visual search patterns and reaction movement in taekwondo according to expertise. *J Sport Exerc Psychol.* (2010) 32:S99–S100. doi: 10.1123/jsep.32.1.99
25. Fontani G, Lodi L, Felici A, Migliorini S, Corradeschi F. Attention in athletes of high and low experience engaged in different open skill sports. *Percept Mot Skills.* (2006) 102(3):791–805. doi: 10.2466/pms.102.3.791-805
26. Milazzo N, Farrow D, Fournier JF. Effect of implicit perceptual-motor training on decision-making skills and underpinning gaze behavior in combat athletes. *Percept Mot Skills.* (2016) 123(1):300–23. doi: 10.1177/0031512516656816
27. Ruiz LM, Peñaloza R, Navia JA, Rioja N. Analysis of the visual behaviour of taekwondists of different skills level. *Rev Mex Psicol.* (2013) 30(1):32–40.
28. Salb S, Splitt M, Bandow N, Witte K. The influence of spatial occlusion on visual search behavior of karate athletes. Pfeiffer T. & Essig K. (Hrsg.) *Proceedings of the 2nd International Workshop on Solutions for Automatic Gaze Data Analysis 2015 (SAGA 2015)*; (2015).
29. Vieten M, Scholz M, Kilani H, Kohloeff M. Reaction time in taekwondo. *ISBS-Conference Proceedings Archive* (2007).
30. Bianco M, Ferri M, Fabiano C, Scardingo A, Tavella S, Caccia A, et al. Comparison of baseline neurophysiological testing in amateur versus professional boxers. *Phys Sportsmed.* (2008) 36(1):95–102. doi: 10.3810/psm.2008.12.17
31. Vences Brito A, Silva C, Cid L, Ferreira D, Marques A. Atención y tiempo de reacción en practicantes de kárate shotokan. *Rev Artes Marciales Asiáticas.* (2011) 6(1):141–56. doi: 10.18002/rama.v6i1.88
32. Chan JS, Wong AC, Liu Y, Yu J, Yan JH. Fencing expertise and physical fitness enhance action inhibition. *Psychol Sport Exerc.* (2011) 12(5):509–14. doi: 10.1016/j.psychsport.2011.04.006
33. Gutierrez-Davila M, Rojas FJ, Antonio R, Navarro E. Response timing in the lunge and target change in elite versus medium-level fencers. *Eur J Sport Sci.* (2011) 13(4):364–71. doi: 10.1080/17461391.2011.635704
34. Sanchez-Lopez J, Silva-Pereyra J, Fernandez T. Sustained attention in skilled and novice martial arts athletes: a study of event-related potentials and current sources. *PeerJ.* (2016) 4:e1614. doi: 10.7717/peerj.1614
35. de Quel OM, Bennett SJ, dan EL, Zapico AG, Morales FS. Choice reaction time is not related to competition success in karate combat. *Eur J Hum Mov.* (2015) 35:41–50.
36. Ripoll H, Kerlirzin Y, Stein JF, Reine B. Analysis of information processing, decision making, and visual strategies in complex problem solving sport situations. *Hum Mov Sci.* (1995) 14(3):325–49. doi: 10.1016/0167-9457(95)00019-0
37. Vickers JN. *Perception, Cognition, and Decision Training: The Quiet Eye in Action*. Champaign, USA: Human Kinetics (2007).
38. Vater C, Williams AM, Hossner EJ. What do we see out of the corner of our eye? The role of visual pivots and gaze anchors in sport. *Int Rev Sport Exerc Psychol.* (2020) 13(1):81–103. doi: 10.1080/1750984X.2019.1582082
39. Darwin C. *The Expression of the Emotions in Man and Animals*. London: John Murray (1872).
40. Corneanu CA, Simón MO, Cohn JF, Guerrero SE. Survey on rgb, 3d, thermal, and multimodal approaches for facial expression recognition: history, trends, and affect-related applications. *IEEE Trans Pattern Anal Mach Intell.* (2016) 38(8):1548–68. doi: 10.1109/TPAMI.2016.2515606
41. Shields K, Engelhardt PE, Ietswaart M. Processing emotion information from both the face and body: an eye-movement study. *Cogn Emot.* (2012) 26(4):699–709. doi: 10.1080/02699931.2011.588691
42. Zhu J, Thagard P. Emotion and action. *Philos Psychol.* (2002) 15(1):19–36. doi: 10.1080/09515080120109397
43. Cheshin A, Heerdink MW, Kossakowski JJ, van Kleef GA. Pitching emotions: the interpersonal effects of emotions in professional baseball. *Front Psychol.* (2016) 7:128. doi: 10.3389/fpsyg.2016.00178
44. Shih YL, Lin CY. The relationship between action anticipation and emotion recognition in athletes of open skill sports. *Cogn Process.* (2016) 17(3):259–68. doi: 10.1007/s10339-016-0764-7
45. Prigent E, Hansen C, Baurès R, Darracq C, Amorim M-A. Predicting where a ball will land: from thrower's body language to ball's motion. *Exp Brain Res.* (2015) 233:567–76. doi: 10.1007/s00221-014-4137-0
46. Peeters P, Vlaeyen J. Feeling more pain, yet showing less: the influence of social threat on pain. *J Pain.* (2011) 12(12):1255–61. doi: 10.1016/j.jpain.2011.07.007
47. Mudric M, Cuk I, Nedeljkovic A, Jovanovic S, Jaric S. Evaluation of video-based method for the measurement of reaction time in specific sport situation. *Int J Perform Anal Sport.* (2015) 15(3):1077–89. doi: 10.1080/24748668.2015.11868852
48. Petri K, Emmermacher P, Danneberg M, Masik S, Eckardt F, Weichelt S, et al. Training using virtual reality improves response behavior in karate kumite. *Sports Eng.* (2019) 22(1):2. doi: 10.1007/s12283-019-0299-0
49. Ran GM, Chen X, Pan YG, Hu TQ, Ma J. Effects of anticipation on perception of facial expressions. *Percept Mot Skills.* (2014) 118(1):195–209. doi: 10.2466/24.PMS.118k13w4
50. Satterthwaite FE. An approximate distribution of estimates of variance components. *Biometrics.* (1946) 2(6):110–4. doi: 10.2307/3002019
51. Luke SG. Evaluating significance in linear mixed-effects models in R. *Behav Res Methods.* (2017) 49:1494–502. doi: 10.3758/s13428-016-0809-y
52. Abernethy B, Zawi K, Jackson RC. Expertise and attunement to kinetic constraints. *Perception.* (2005) 37(6):931–48. doi: 10.1068/p5340
53. Williams AM, Davids K. Visual search strategy, selective attention and expertise in soccer. *Res Q Exerc Sport.* (1998) 69(2):111–28. doi: 10.1080/02701367.1998.10607677
54. Bianco M, Ferri M, Fabiano C, Giorgiano F, Tavella S, Manili U, et al. Baseline simple and complex reaction times in female compared to male boxers. *J Sports Med Phys Fitness.* (2011) 51(2):292–8.
55. Branco M, Branco G, Vences Brito A. Introduction to data collection for performance analysis and their integration in martial arts training. A biomechanical and motor control perspective. *Rev Artes Marciales Asiáticas.* (20016) 11(2s):19–21. doi: 10.18002/rama.v11i2s.4152
56. Guizani SM, Bouzaouach I, Tenenbaum G, Kheder AB. Simple and choice reaction times under varying levels of physical load in high skilled fencers. *J Sports Med Phys Fitness.* (2006) 46(2):344.
57. Donovan OO, Cheung J, Catley M, McGregor AH, Strutton PH. An investigation of leg and trunk strength and reaction times of hard-style martial arts practitioners. *J Sports Sci Med.* (2006) 5:5–12.
58. Eimer M. Event-related brain potentials distinguish processing stages involved in face perception and recognition. *Clin Neurophysiol.* (2000) 111(4):694–705. doi: 10.1016/S1388-2457(99)00285-0
59. Thierry G, Pegna AJ, Dodds C, Roberts M, Basan S, Downing P. An event-related potential component sensitive to images of the human body. *NeuroImage.* (2006) 32(2):871–9. doi: 10.1016/j.neuroimage.2006.03.060
60. Chandrasekaran C, Turner L, Buelthoff HH, Thornton IM. Attentional networks and biological motion. *Psyhologija.* (2010) 43(1):5–20. doi: 10.2298/PSI1001005C

61. Cutting JE, Moore C, Morrison R. Masking the motions of human gait. *Percept Psychophys.* (1988) 44(4):339–47. doi: 10.3758/BF03210415
62. Troje NF, Westhoff C. The inversion effect in biological motion perception: evidence for a “life detector”? *Curr Biol.* (2006) 16(8):821–4. doi: 10.1016/j.cub.2006.03.022
63. Kuhlmeier VA, Troje NF, Lee V. Young infants detect the direction of biological motion in point-light displays. *Infancy.* (2010) 15(1):83–93. doi: 10.1111/j.1532-7078.2009.00003.x
64. Simion F, Regolin L, Bulf H. A predisposition for biological motion in the newborn baby. *Proc Natl Acad Sci U S A.* (2008) 105(2):809–13. doi: 10.1073/pnas.0707021105
65. Simion F, Di Giorgio E, Leo I, Bardi L. The processing of social stimuli in early infancy: from faces to biological motion perception. *Prog Brain Res.* (2011) 189:173–93. doi: 10.1016/B978-0-444-53884-0.00024-5
66. Adolph KE, Franchak JM. The development of motor behavior. *Wiley Interdiscip Rev Cogn Sci.* (2017) 8(1-2):e1430. doi: 10.1002/wcs.1430
67. Czyż SH. Variability of practice, information processing, and decision making—how much do we know? *Front Psychol.* (2021) 12:639131. doi: 10.3389/fpsyg.2021.639131
68. Merk A, Resnick A. Physics of martial arts: incorporation of angular momentum to model body motion and strikes. *PLoS One.* (2021) 16(8):e0255670. doi: 10.1371/journal.pone.0255670



## OPEN ACCESS

## EDITED BY

Lazar Toskić,  
University of Pristina, Serbia

## REVIEWED BY

Valdemar Štajer,  
University of Novi Sad, Serbia  
Nikola Aksović,  
University of Pristina, Serbia

## \*CORRESPONDENCE

Meric Eraslan  
✉ mericeraslan@akdeniz.edu.tr  
Laurentiu-Gabriel Talaghir  
✉ gabriel.talaghir@ugal.ro

RECEIVED 10 October 2024

ACCEPTED 28 November 2024

PUBLISHED 06 December 2024

## CITATION

Seker R, Isik O, Durukan E, Eraslan M, Talaghir L-G and Dorgan V (2024) Determination of weight loss methods and effects among wrestlers before an official championship. *Front. Nutr.* 11:1505759. doi: 10.3389/fnut.2024.1505759

## COPYRIGHT

© 2024 Seker, Isik, Durukan, Eraslan, Talaghir and Dorgan. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# Determination of weight loss methods and effects among wrestlers before an official championship

Ramazan Seker<sup>1</sup>, Ozkan Isik<sup>2</sup>, Erdil Durukan<sup>2</sup>, Meric Eraslan<sup>3\*</sup>, Laurentiu-Gabriel Talaghir<sup>4\*</sup> and Viorel Dorgan<sup>4</sup>

<sup>1</sup>Faculty of Sport Sciences, Hatay Mustafa Kemal University, Hatay, Türkiye, <sup>2</sup>Faculty of Sports Sciences, Balıkesir University, Balıkesir, Türkiye, <sup>3</sup>Faculty of Sports Sciences, Akdeniz University, Antalya, Türkiye, <sup>4</sup>Faculty of Physical Education and Sport, Dunarea de Jos University of Galati, Galati, Romania

**Introduction:** It is known that combat athletes frequently lose weight before a competition. This study aimed to determine the weight loss methods before an official championship and the effects of these weight loss methods on the performance of wrestlers.

**Method:** The sample of the study consisted of 350 competitive wrestlers. The "Athlete Weight Loss Methodology and Effects Scale" and personal information form were used as data collection tools in the study. In the data analysis, independent samples T-test, One-way ANOVA, and Pearson correlation analysis were used in addition to descriptive statistics.

**Results:** Wrestlers generally reported dieting by restricting fatty (89.1%) and carbohydrate (83.4%) foods. It was observed that they preferred jogging with a raincoat (89.1%) and/or using the sauna (79.7%) as a weight loss method. Wrestlers also reported that they performed weight loss, although at a low level, by using ergogenic aids such as laxatives (31.7%) and/or diuretic pills (28.0%). They were observed to experience physiological effects such as muscle cramps (72.9%), injury (71.1%), and/or difficulty breathing (60.9%), as well as psychological effects such as feeling extremely tired (81.7%), stress (79.7%), decreased performance (78.6%) and/or extremely irritability (71.4%). It was determined that there was no difference between the weight loss methods and effects of the wrestlers according to their gender and wrestling style ( $p > 0.05$ ). On the other hand, it was determined that the diet level of U20 wrestlers was higher than U17 ( $p < 0.05$ ) and Senior wrestlers and that U17 and U20 wrestlers were exposed to higher levels of physiological and psychological effects than Senior wrestlers ( $p < 0.05$ ).

**Conclusion:** It was determined that wrestlers preferred methods such as restricting food and fluids, using a sauna, and jogging with a raincoat to lose weight. It is necessary to prevent young wrestlers from losing weight before the competition. Thus, it is possible to prevent wrestlers in their development period (U17 and U20) from being exposed to physiological and psychological effects caused by losing weight.

## KEYWORDS

dehydration, ergogenic aids, food restriction, rapid weight loss, wrestling

# 1 Introduction

Nearly 22% of the total medals at the 2024 Paris Olympic Games were awarded in combat sports. A total of 232 medals were awarded in five different combat sports (boxing, fencing, judo, taekwondo, and wrestling) at the 2024 Paris Olympic Games, and wrestling had the most medals in combat sports with 72 medals (1). Although wrestling has recently (before the 2020 Tokyo Olympic Games) faced the threat of being dropped from the Olympic Games, wrestling as one of the oldest combat sports has maintained a place in the modern Olympic Games since the Ancient Greek Olympic Games of 708 B.C.E (2). In the modern Olympics, there are three different wrestling styles: Greco-Roman (GR), Free-Style (FS), and women's wrestling (WW) (3).

To prevent unfair competition, wrestlers are matched according to their body weight and gender (4). Therefore, to gain a competitive advantage against weaker and smaller opponents than themselves, many athletes lose weight rapidly before the competition (5). Although the negative effects of Rapid Weight Loss (RWL) on health status (athletic performance, body composition, competitive success, and injury, etc.) are well reported (6–9), previous studies have reported that 60–90% of high school, collegiate, and/or international level wrestlers experience RWL (10–13).

Various RWL methods such as food and fluid restriction, using a sauna, jogging in a raincoat, and using laxatives, diet pills and/or diuretics are widely used by wrestlers. Physical (body weight, body mass index, and body composition, etc.) and physiological (basal metabolic rate, total body water, free-fat mass, and fat mass, etc.) changes occur in the organism due to food and fluid restriction (14–16). Using a sauna and jogging in a raincoat accelerates fluid excretion from the body through sweat, and the decrease in body water in both intracellular and extracellular spaces increases physiological stress in the human body (17). Moreover, Isik et al. (18) reported that wrestlers may be exposed to hyperosmolar pressure and may exhibit hypernatremic responses (thirst, increased urine concentration, muscle cramps, dry skin and mouth, confusion, seizures or coma, etc.) due to increased sodium levels depending to decreased fluid levels in the body. Although the use of diuretics is not a preferred method due to being on the WADA list, it is a method preferred by non-Olympic wrestlers for RWL from time to time in local or championships without doping control. RWL with all these methods can affect wrestlers physiologically and expose them to many negative psychological effects. RWL has been reported to cause psychological effects in athletes such as decreased short-term memory, vigor, concentration, and self-esteem, as well as increased confusion, anger, fatigue, depression, and isolation, all of which can hamper competitive performance. For example, decreased short-term memory can impact the ability of an athlete to follow his/her coach's instructions before a match. Likewise, the lack of concentration and focus can affect the athlete's ability to deal with distractions during high-level competitions, resulting in poor performance. A low self-esteem may result in difficulty in considering the possibility of winning a match, especially against high-level opponents. Confusion can negatively affect the capacity to make decisions during a competition and anger may result in a lack of control and, despite the importance of aggressiveness in combat sports, excessive anger may increase the possibility of illegal actions (19).

In order to eliminate all these physiological and psychological effects and to prioritize human health, United World Wrestling (UWW) has tried to take various precautions such as reducing the

~16-h period between the weigh-in time and the competition time to 2 h and finishing all competitions (except repackages and medal matches) in one day, but UWW has not been able to prevent it completely. Therefore, despite all these protective rule changes made by UWW, it is important to determine the weight loss methods of wrestlers and the effects of these methods on wrestlers. In this context, this study aimed to determine the weight loss methods of female and male wrestlers competing in different age categories and wrestling styles before an official competition and to reveal the possible physiological and psychological effects of these weight loss methods.

# 2 Methods

## 2.1 Research design and participants

This study was a cross-sectional study, and a purposeful sampling method was used in the selection of participants. Three hundred and eighty-eight wrestlers were initially included in the study. Thirty-eight of the wrestlers were excluded from the study because they did not lose weight. Therefore, the study sample was included in three hundred and fifty wrestlers.

## 2.2 Data collection tools

In the study, data was obtained from wrestlers voluntarily using the online survey method via Google Forms. In addition to the personal information form, the athlete weight loss methods and effects scale were used as measurement tools.

### 2.2.1 Personal information form

The personal information form included questionnaires asking about the wrestlers' gender, wrestling style, age category, how many days before the competition they lost weight, and the amount of weight loss.

### 2.2.2 Athlete weight loss methodology and effects scale

To determine the weight loss methods of wrestlers and the possible effects of these methods, the "Athlete weight loss methodology and effects scale" developed by Yazar et al. (20) and a personal information form were used. The Athlete weight loss methodology and effects scale was a five-point Likert-type (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Frequently, 5 = Always) scale consisting of nineteen questions divided into five sub-dimensions as diet (3 items), dehydration (3 items), ergogenic aids (3 items), physiological effect (5 items), and psychological effect (5 items). The reliability coefficient (Cronbach's alpha) for the original Athlete weight loss methodology and effects scale was 0.74. In this study, Cronbach's alpha coefficient for Athlete weight loss methodology and effects scale was determined as 0.81. This result shows that the Athlete weight loss methodology and effects scale was reliable for our study sample.

## 2.3 Ethical approval

This study was ethically approved by the Balikesir University Health Sciences Non-invasive Research Ethics Committee with the



decision numbered 2024/137. The parents of the U18 wrestlers who participated in the study were not in the competition area. For this reason, legal permission was obtained from the coaches of the U18 wrestlers as the legal representatives for data collection. In addition, informed consent was approved from all participants before answering the questions.

## 2.4 Statistical analysis

In addition to descriptive statistics (i.e., percent and frequency), the Kolmogorov–Smirnov test was used for the normality test. In the analysis of normally distributed data, the independent samples t-test was used for comparison according to gender. One-way ANOVA was used to compare wrestling style and age categories. The LSD post-hoc test was applied to determine the source of the difference between groups of age categories. A Pearson correlation analysis was used to determine the relationship between sub-dimensions of weight loss methods and effects scale. Significance was set at  $p < 0.05$  and  $p < 0.01$ , respectively.

## 3 Results

Wrestlers who followed a diet to lose weight reported that they reduced their total food consumption by 79.7%, and specifically reduced their dietary fat and carbohydrate consumption by 89.1 and 83.4%, respectively. When the dehydration methods used by wrestlers to lose weight were examined, it was determined that 89.1% of them jogged with a raincoat, 79.7% used saunas and only 26% tried to lose weight by spitting. When the ergogenic aids consumed by wrestlers to lose weight were examined, it was determined that 31.7% used laxatives, 27.1% used diet pills, and 28.0% tried to lose weight by using diuretic pills (Table 1).

When the physiological effects of weight loss were examined in wrestlers, they reported that they were exposed to muscle cramps, injuries, difficulty breathing, increased body temperature, and heart palpitations with the prevalence of 72.9, 71.1, 60.9, 57.3, and 48.0%, respectively. When the psychological effects of weight loss were examined in wrestlers, they reported that they were exposed to extremely tired, stressed, decreased performance, extremely irritable, and decreased desire to do sports by 81.7, 79.7, 78.6, 71.4, and 66.3%, respectively (Table 2).

It was determined that the sub-dimensions of all of the weight loss methods (diet, dehydration, and ergogenic aids) and effects (physiological and psychological) were positively and moderately related to each other. Moreover, a negative and low correlation was found between the ergogenic aids and the diet sub-dimensions. This correlation shows that those using ergogenic aids do not restrict food and fluids (Table 3).

Of the wrestlers participating in the study, 42.86% ( $n = 150$ ) were female and 57.14% ( $n = 200$ ) were male. When classified according to wrestling styles, 40% ( $n = 140$ ) were FS, 17.14% ( $n = 60$ ) were GR and 42.86% ( $n = 150$ ) were WW competitors. 23.43% ( $n = 82$ ) of the wrestlers were competing in the U17, 20.00% ( $n = 70$ ) were U20 and 56.57% ( $n = 198$ ) were Senior category. 49.14% of the wrestlers started to lose weight one week before the competitions and wrestlers competing in the Senior category lost more weight ( $4.91 \pm 2.18$  kg)

than wrestlers in the U17 ( $3.00 \pm 1.94$  kg) and U20 ( $3.74 \pm 2.42$  kg) categories (Table 4).

When the wrestlers' sub-dimensions of weight loss methods and effects scale were compared according to gender (Table 5) and wrestling styles (Table 6), it was determined that there was no statistically significant difference for sub-dimensions of weight loss methods and effects scale ( $p > 0.05$ ).

When the wrestlers' sub-dimensions of the weight loss methods and effects scale were compared according to age categories; it was determined that there was no statistically significant difference in the dehydration and ergogenic aids sub-dimensions ( $p > 0.05$ ), whereas there was a statistically significant difference in the diet, physiological and psychological effects sub-dimensions ( $p < 0.05$ ). According to this result, it was determined that U20 wrestlers were exposed to higher levels of dieting than U17 and Senior wrestlers. Moreover, it was determined that Senior wrestlers were exposed to lower levels of physiological and psychological effects than U17 and U20 wrestlers (Table 7).

## 4 Discussion

The primary purpose of this study was to determine the weight loss methods of wrestlers before an official competition and the possible physiological and psychological effects of these methods. When the results of this study were examined, it was determined that the most preferred methods among the weight loss methods were food and fluid restriction, running with a raincoat, and using the sauna. It was determined that losing weight by spitting and using laxatives, diet pills, and diuretic pills were not preferred much (Table 1). Due to the weight loss, wrestlers reported that they experienced physiological effects such as muscle cramps (72.9%), injuries (71.1%), difficulty breathing (60.9%), increased body temperature (57.3%) and heart palpitations (48%), and psychologically, they felt extremely tired (81.7%), stressed (79.7%), decreased performance (78.6%), extremely irritability (71.4%) and decreased desire to do sports (66.3%) (Table 2).

Especially in combat sports, although the negative effects of RWL are well-known, athletes still prefer using various methods for RWL. For this reason, many scientists continue to conduct various studies on the effects of RWL. For example, when biochemical studies on RWL were examined, it was reported that RWL causes acute kidney injuries (13), failure to reduce muscle damage markers to basal levels as a metabolic response (21) and extended recovery time (22), increases in plasma osmolarity and ghrelin hormone levels (15), increases in cortisol levels, but decreases in testosterone levels (23). In addition to all these biochemical results, despite conflicting evidence, most studies show that weight loss reduces both aerobic and anaerobic performance. Aerobic performance impairments have been attributed to dehydration, decreased plasma volume, increased heart rate, hydroelectrolytic disturbances, impaired thermoregulation, and muscle glycogen depletion, whereas decreased anaerobic performance has been attributed primarily to decreased buffering capacity, glycogen depletion, and hydroelectrolytic disturbances (19). Moreover, it was reported that they were exposed to muscle cramps, injury, and heart palpitations (2) and may show hypernatremic responses due to increased plasma osmolarity (18) during RWL. When the psychological results of the studies on RWL were examined, Filaire et al. (24) reported that after a seven-day food restriction, tension,



TABLE 1 Examination of weight loss methods in an official competition among wrestlers.

Items of diet sub-dimensions	Likert	f	%	No/Yes
Item 1: I reduce food consumption	Never	71	20.3	20.3
	Rarely	114	32.6	79.7
	Sometimes	96	27.4	
	Often	52	14.9	
	Always	17	4.9	
Item 2: I reduce the consumption of carbohydrate foods	Never	38	10.9	10.9
	Rarely	139	39.7	89.1
	Sometimes	96	27.4	
	Often	53	15.1	
	Always	24	6.9	
Item 3: I reduce the consumption of fatty food	Never	30	8.6	8.6
	Rarely	115	32.9	83.4
	Sometimes	95	27.1	
	Often	79	22.6	
	Always	31	8.9	
Items of dehydration sub-dimensions	Likert	f	%	No/Yes
Item 4: I jog with a raincoat	Never	38	10.9	10.9
	Rarely	93	26.6	89.1
	Sometimes	107	30.6	
	Often	68	19.4	
	Always	44	12.6	
Item 5: I go to the sauna	Never	71	20.3	20.3
	Rarely	108	30.9	79.7
	Sometimes	97	27.7	
	Often	58	16.6	
	Always	16	4.6	
Item 6: I lose weight by spitting	Never	259	74.0	74.0
	Rarely	45	12.9	26.0
	Sometimes	28	8.0	
	Often	13	3.7	
	Always	5	1.4	
Items of ergogenic aids sub-dimensions	Likert	f	%	No/Yes
Item 7: I use laxatives (diarrheals)	Never	239	68.3	68.3
	Rarely	62	17.7	31.7
	Sometimes	35	10.0	
	Often	11	3.1	
	Always	3	0.9	
Item 8: I use diet pills	Never	255	72.9	72.9
	Rarely	54	15.4	27.1
	Sometimes	27	7.7	
	Often	11	3.1	
	Always	3	0.9	
Item 9: I use diuretic pills	Never	252	72.0	72.0
	Rarely	53	15.1	28.0
	Sometimes	31	8.9	
	Often	13	3.7	
	Always	1	0.3	

TABLE 2 Examination of weight loss effects in an official competition among wrestlers.

Items of physiological effect sub-dimensions	Likert	f	%	No/Yes
Item 10. I experience muscle cramps	Never	95	27.1	27.1
	Rarely	107	30.6	72.9
	Sometimes	92	26.3	
	Often	43	12.3	
	Always	13	3.7	
Item 11. My body temperature increases (I get a fever)	Never	150	42.9	42.9
	Rarely	105	30.0	57.3
	Sometimes	60	17.1	
	Often	25	7.1	
	Always	10	2.9	
Item 12. I experience heart palpitations	Never	182	52.0	52.0
	Rarely	97	27.7	48.0
	Sometimes	51	14.6	
	Often	13	3.7	
	Always	7	2.0	
Item 13. I experience difficulty breathing	Never	137	39.1	39.1
	Rarely	129	36.9	60.9
	Sometimes	57	16.3	
	Often	20	5.7	
	Always	7	2.0	
Item 14. I experience injury	Never	101	28.9	28.9
	Rarely	121	34.6	71.1
	Sometimes	84	24.0	
	Often	30	8.6	
	Always	14	4.0	
Items of psychological effect sub-dimensions	Likert	f	%	No/Yes
Item 15: I become extremely irritable	Never	100	28.6	28.6
	Rarely	106	30.3	71.4
	Sometimes	75	21.4	
	Often	40	11.4	
	Always	29	8.3	
Item 16: I feel extremely tired	Never	64	18.3	18.3
	Rarely	120	34.3	81.7
	Sometimes	86	24.6	
	Often	51	14.6	
	Always	29	8.3	
Item 17: My performance decreases	Never	75	21.4	21.4
	Rarely	161	46.0	78.6
	Sometimes	81	23.1	
	Often	24	6.9	
	Always	9	2.6	
Item 18: I get stressed	Never	71	20.3	20.3
	Rarely	140	40.0	79.7
	Sometimes	88	25.1	
	Often	31	8.9	
	Always	20	5.7	
Item 19: My desire to do sports decreases	Never	118	33.7	33.7
	Rarely	136	38.9	66.3
	Sometimes	67	19.1	
	Often	18	5.1	
	Always	11	3.1	

TABLE 3 The relationship between sub-dimensions of weight loss methods and effects scale among wrestlers.

Sub-dimensions of weight loss methods and effects scale		Diet	Dehydration	Ergogenic aids	Physiological effect	Psychological effect
Diet	<i>r</i>	1				
	<i>p</i>					
Dehydration	<i>r</i>	0.194**	1			
	<i>p</i>	0.000				
Ergogenic aids	<i>r</i>	−0.183**	0.223**	1		
	<i>p</i>	0.001	0.000			
Physiological effect	<i>r</i>	0.113*	0.266**	0.430**	1	
	<i>p</i>	0.034	0.000	0.000		
Psychological effect	<i>r</i>	0.210**	0.178**	0.170**	0.560**	1
	<i>p</i>	0.000	0.001	0.001	0.000	

\**p* < 0.05; \*\**p* < 0.01.

TABLE 4 Distribution of personal information of wrestlers.

Personal information	Categories	<i>f</i>	%	Mean ± std. deviation
Gender	Women	150	42.86	-
	Men	200	57.14	-
Wrestling styles	FS	140	40.00	-
	GR	60	17.14	-
	WW	150	42.86	-
Age Categories	U17	82	23.43	-
	U20	70	20.00	-
	Senior	198	56.57	-
How many days before the competition do you start losing weight?	<1 week	172	49.14	-
	1–2 week	77	22.00	-
	3–4 week	81	23.14	-
	≥5 week	20	5.72	-
What are your weight loss amounts according to age groups? (kg)	U17	82	-	3.00 ± 1.94
	U20	70	-	3.74 ± 2.42
	Senior	198	-	4.91 ± 2.18

anger, fatigue, and confusion were significantly increased, and vigor was significantly decreased in judokas. Isik et al. (25) reported that as the amount of weight loss in wrestlers increased, their depression levels also increased. Slacanac et al. (26) reported that somatic anxiety increased and self-confidence, task orientation, interest/enjoy, and competence decreased due to RWL in Croatian wrestlers. The physiological and psychological results of the studies in the literature on RWL support the results of our study.

When the relationship between the weight loss methods and the sub-dimensions of the measurement tool used to determine their effects was examined in our study, it was determined that there was a positive and moderate relationship between the diet, dehydration, and ergogenic aids methods and both physiological and psychological effect sub-dimensions. Among the weight loss methods, a negative

low-level relationship existed between ergogenic aids and the diet sub-dimension (Table 3). This result suggests that among the wrestlers who lost weight before a competition, those who did not restrict food and fluid preferred ergogenic aids (laxatives, diet pills and/or diuretics) to lose weight. In summary, laxative use causes motility in the bowel and diarrhea. However, long-term use can disrupt your bowel habits and cause side effects. On the other hand, diuretics increase urine volume (urine excretion rate). However, diuretics affect the nephrons and tubules in the kidneys, reduce water reabsorption and increase the volume of urine excreted. So, athletes are weighed with an empty stomach and bladder before the competition weigh-in.

The secondary purpose of this study was to determine whether the weight loss methods and their effects differed according to gender, wrestling style, and age categories. According to the results of our study, it was determined that there was no difference between the weight loss methods and the effects of these methods between both female and male wrestlers (Table 5). In addition, there was no difference between the weight loss methods and their effects in terms of wrestling styles (FS, GR, and WW) (Table 6). In a previous study, it was reported that gender was not an effective factor in achieving RWL (19). Wrestling styles were also indirectly related to gender. Because only men were divided into two as FS and GR, and only FS wrestling competitions were held for women and were called WW. However, when weight loss methods were examined according to age groups, there was a difference in the diet sub-dimension according to age categories (Table 7). According to this result, it was seen that the wrestlers in the senior category had lower diet scores and dieted at a lower level than the wrestlers in the U17 and U20 classes. When the effects of weight loss were examined, there was a difference according to age categories in both physiological and psychological effects (Table 7). It was observed that wrestlers in the senior category had lower average scores in both physiological and psychological effects sub-dimensions. This result shows that the wrestlers in the senior class experienced high levels of weight loss despite having lower levels of food and fluid restrictions (Table 4). This result suggested that they either had a longer exercise duration or were less affected physiologically and psychologically because they adapted to losing weight.

When tragic scenes related to weight loss were examined, a judoka was found dead of a heart attack in the sauna in 1996 (27). In

TABLE 5 Comparison of sub-dimensions of weight loss methods and effects on wrestlers according to their gender.

Sub-dimensions of weight loss methods and effects scale	Gender	N	Mean $\pm$ std. deviation	t	p
Diet	Women	150	2.78 $\pm$ 1.00	1.607	0.109
	Men	200	2.62 $\pm$ 0.86		
Dehydration	Women	150	2.26 $\pm$ 0.62	−1.599	0.111
	Men	200	2.37 $\pm$ 0.66		
Ergogenic aids	Women	150	1.45 $\pm$ 0.74	−0.265	0.791
	Men	200	1.47 $\pm$ 0.72		
Physiological effect	Women	150	2.10 $\pm$ 0.75	1.136	0.256
	Men	200	2.01 $\pm$ 0.74		
Psychological effect	Women	150	2.40 $\pm$ 0.83	1.371	0.170
	Men	200	2.28 $\pm$ 0.79		

p > 0.05.

TABLE 6 Comparison of sub-dimensions of weight loss methods and effects on wrestlers according to their wrestling style.

Sub-dimensions of weight loss methods and effects scale	Wrestling style	N	Mean $\pm$ std. deviation	F	p
Diet	FS	140	2.66 $\pm$ 0.85	0.914	0.402
	GR	60	2.60 $\pm$ 0.88		
	WW	150	2.77 $\pm$ 1.02		
Dehydration	FS	140	2.29 $\pm$ 0.65	1.466	0.232
	GR	60	2.45 $\pm$ 0.68		
	WW	150	2.30 $\pm$ 0.62		
Ergogenic aids	FS	140	1.43 $\pm$ 0.74	0.432	0.650
	GR	60	1.53 $\pm$ 0.67		
	WW	150	1.48 $\pm$ 0.75		
Physiological effect	FS	140	2.03 $\pm$ 0.75	0.232	0.793
	GR	60	2.11 $\pm$ 0.69		
	WW	150	2.06 $\pm$ 0.76		
Psychological effect	FS	140	2.37 $\pm$ 0.86	0.208	0.812
	GR	60	2.31 $\pm$ 0.57		
	WW	150	2.32 $\pm$ 0.84		

p > 0.05.

1997, the deaths of three college wrestlers shocked the wrestling community. Autopsies recorded the wrestlers’ cause of death as dehydration (28). At the 2000 Sydney Olympic Games, Deborah Allan’s coach cut her hair because she weighed 400 grams overweight, and even though she weighed naked, she was disqualified because she still was 100 grams overweight (29). In a very close result, Vinesh Phogat, who qualified to compete in the 50 kg final at the 2024 Paris Olympic Games, was disqualified for weighing more than 52 kg at the pre-competition weigh-in time on the final day (30). As a result, it can be considered that weight loss may detract from competition success as well as health-related physiological and psychological effects and may even cause death. Although hundreds of thousands of studies on RWL are well documented its negative effects, it is still incomprehensible that competitive athletes continue to experience RWL, which exposes them to physiological and psychological effects that disregard human health.

## 5 Conclusion

As a result of the study, it was determined that wrestlers often preferred methods such as restricting food and fluids, using a sauna, and running with a raincoat to lose weight, but they rarely preferred ergogenic aids. It was observed that they were exposed physiologically to muscle cramps, injuries, difficulty breathing, increased body temperature, and heart palpitations, and psychologically to extremely tired, stressed, decreased performance, extremely irritable, and decreased desire to do sports.

### 5.1 Suggestions

Especially in an official wrestling competition, the time between the weigh-in time and the competition is approximately 2 h, so wrestlers

TABLE 7 Comparison of sub-dimensions of weight loss methods and effects scale on wrestlers according to their age categories.

Sub-dimensions of weight loss methods and effects scale	Age categories	N	Mean $\pm$ std. deviation	F	p
Diet	U17	82	2.78 $\pm$ .94 <sup>ab</sup>	3.576	0.029*
	U20	70	2.91 $\pm$ .92 <sup>a</sup>		
	Senior	198	2.59 $\pm$ .92 <sup>b</sup>		
Dehydration	U17	82	2.26 $\pm$ 0.68	1.072	0.343
	U20	70	2.41 $\pm$ 0.71		
	Senior	198	2.31 $\pm$ 0.61		
Ergogenic aids	U17	82	1.49 $\pm$ 0.71	0.089	0.914
	U20	70	1.44 $\pm$ 0.78		
	Senior	198	1.46 $\pm$ 0.73		
Physiological effect	U17	82	2.34 $\pm$ .77 <sup>a</sup>	17.594	0.001**
	U20	70	2.27 $\pm$ .77 <sup>a</sup>		
	Senior	198	1.86 $\pm$ .66 <sup>b</sup>		
Psychological effect	U17	82	2.54 $\pm$ .84 <sup>a</sup>	9.155	0.001**
	U20	70	2.55 $\pm$ .76 <sup>a</sup>		
	Senior	198	2.18 $\pm$ .78 <sup>b</sup>		

\* $p < 0.05$ ; \*\* $p < 0.01$ ; <sup>ab</sup>: different letter shows statistical differences between groups according to the LSD post-hoc test.

should avoid RWL and dehydration. If wrestlers are required to lose weight for a competition, they should perform their weight loss processes more extensively. Thus, the physiological and psychological effects of weight loss will decrease. Athletes who lose more than 5% of their body weight for a competition should consider moving up to a higher weight category to prevent them from experiencing the effects of weight loss.

## 5.2 Limitations of the study

Of course, this research also had some limitations like every study. The first limitation is that no biochemical markers were used to determine physiological and psychological effects in this study. In future studies, the data obtained through the survey should be supported by biochemical parameters. Secondly, this study used the survey technique, which was one of the quantitative research methods. In addition to quantitative research methods for these research variables in future studies, interview and/or observation analyses from qualitative research methods can be used, or mixed research methods can be used.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Ethics statement

The studies involving humans were approved by Balikesir University Health Sciences Non-invasive Research Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for

participation in this study was provided by the participants' legal guardians/next of kin.

## Author contributions

RS: Investigation, Methodology, Writing – original draft, Writing – review & editing. OI: Investigation, Methodology, Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Formal analysis. ED: Data curation, Investigation, Methodology, Writing – review & editing. ME: Investigation, Writing – original draft, Writing – review & editing. L-GT: Funding acquisition, Writing – original draft, Writing – review & editing. VD: Funding acquisition, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.



## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated

organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Paris Olympic Games (2024). Available at: <https://olympics.com/en/paris-2024/medals>
- Yagmur R, Isik O, Kilic Y, Dogan I. Weight loss methods and effects on the elite cadet Greco-Roman wrestlers. *J Teach Res Media Kinesiol.* (2019) 5:33–40.
- Roklicer R, Rossi C, Bianco A, Stajer V, Ranisavljev M, Todorovic N, et al. Prevalence of rapid weight loss in Olympic style wrestlers. *J Int Soc Sports Nutr.* (2022) 19:593–602. doi: 10.1080/15502783.2022.2119095
- Kim JC, Park KJ. Injuries and rapid weight loss in elite Korean wrestlers: an epidemiological study. *Phys Sportsmed.* (2021) 49:308–15. doi: 10.1080/00913847.2020.1824536
- Zhong Y, Song Y, Artioli GG, Gee TI, French DN, Zheng H, et al. The practice of weight loss in combat sports athletes: a systematic review. *Nutrients.* (2024) 16:1050. doi: 10.3390/nu16071050
- Alpay CB, Isik O. Comparison of body components and balance levels among hearing-impaired wrestlers and healthy wrestlers. *Acta Kinesiologica.* (2017) 11:79–84.
- Isik O, Cicioglu HI. Dehydration, skeletal muscle damage and inflammation before the competitions among the elite wrestlers. *J Phys Ther Sci.* (2016) 28:162–8. doi: 10.1589/jpts.28.162
- Milovančev A, Miljković T, Ilić A, Stojić Milosavljević A, Petrović M, Roklicer R, et al. Disrupting arrhythmia in a professional male wrestler athlete after rapid weight loss and high-intensity training—case report. *Front Cardio Med.* (2023) 10:1091603. doi: 10.3389/fcvm.2023.1091603
- Roklicer R, Lakicevic N, Stajer V, Trivic T, Bianco A, Mani D, et al. The effects of rapid weight loss on skeletal muscle in judo athletes. *J Transl Med.* (2020) 18:142–7. doi: 10.1186/s12967-020-02315-x
- Alderman BL, Landers DM, Carlson JOHN, Scott JR. Factors related to rapid weight loss practices among international-style wrestlers. *Med Sci Sports Exerc.* (2004) 36:249–52. doi: 10.1249/01.MSS.0000113668.03443.66
- Oppliger RA, Steen SAN, Scott JR. Weight loss practices of college wrestlers. *Int J Sport Nutr Exerc Metab.* (2003) 13:29–46. doi: 10.1123/ijsnem.13.1.29
- Steen SN, Brownell KD. Patterns of weight loss and regain in wrestlers: has the tradition changed? *Med Sci Sports Exerc.* (1990) 22:762–8. doi: 10.1249/00005768-199012000-00005
- Trivic T, Roklicer R, Zenic N, Modric T, Milovancev A, Lukic-Sarkanovic M, et al. Rapid weight loss can increase the risk of acute kidney injury in wrestlers. *BMJ Open Sport Exerc Med.* (2023) 9:e001617. doi: 10.1136/bmjsem-2023-001617
- Alpay CB, Ersöz Y, Karagöz Ş, Oskouei MM. A comparison of weight loss, body composition and some mineral levels before competition in elite wrestlers. *Int J Sci Cult Sport.* (2015) 3:338–48. doi: 10.14486/IJSCS395
- Cicioglu HI, Isik O, Yildirim I, Unveren A, Karagoz S. The effects of dehydration before competition upon body compositions, leptin hormone and ghrelin hormone among elite wrestlers. *Biomed Res.* (2017) 28:4335–41.
- Isik O, Dogan I. Body components changes and depression scores before competitions among elite female wrestlers. *Acta Kinesiologica.* (2017) 11:23–7.
- Lieberman HR. Hydration and cognition: a critical review and recommendations for future research. *J Am Coll Nutr.* (2007) 26:555S–61S. doi: 10.1080/07315724.2007.10719658
- Isik O, Yildirim I, Ersoz Y, Koca HB, Dogan I, Ulutas E. Monitoring of pre-competition dehydration-induced skeletal muscle damage and inflammation levels among elite wrestlers. *J Back Musculoskeletal Rehabil.* (2018) 31:533–40. doi: 10.3233/BMR-170955
- Franchini E, Brito CJ, Artioli GG. Weight loss in combat sports: physiological, psychological and performance effects. *J Int Soc Sports Nutr.* (2012) 9:1–6. doi: 10.1186/1550-2783-9-52
- Yarar H, Eroğlu H, Uzum H, Polat E. "Athlete weight loss methodology and effects scale": validity and reliability study<p>"Sporcu kilo Düşme Yöntemleri ve Etkileri Ölçeği": Geçerlik ve güvenirlik çalışması. *J Human Sci.* (2016) 13:6164–75. doi: 10.14687/jhs.v13i3.4212
- Lukic-Sarkanovic M, Roklicer R, Trivic T, Manojlovic M, Gilic B, Milovancev A, et al. Acute muscle damage as a metabolic response to rapid weight loss in wrestlers. *Biomed Hum Kinet.* (2024) 16:99–105. doi: 10.2478/bhk-2024-0010
- Isik O, Alpay CB, Hazar S, Eker H. A study examining the effects of changed rules of wrestling competitions on the muscular damage levels of the elite wrestlers. *Turkish J Sport Exerc.* (2014) 16:18–24. doi: 10.15314/TJSE.201416014
- Yildirim I. Associations among dehydration, testosterone and stress hormones in terms of body weight loss before competition. *Am J Med Sci.* (2015) 350:103–8. doi: 10.1097/MAJ.0000000000000521
- Filaire E, Maso F, Degoutte F, Jouanel P, Lac G. Food restriction, performance, psychological state and lipid values in judo athletes. *Int J Sports Med.* (2001) 22:454–9. doi: 10.1055/s-2001-16244
- Isik O, Gokdemir K, Bastik C, Yildirim I, Dogan I. A study in elite wrestlers: weight loss and depression. *Nigde Univ J Phys Educ Sport Sc.* (2013) 7:216–23.
- Slacanac K, Baic M, Hrvoje K. The relationship between rapid weight loss indicators and selected psychological indicators on success of Croatian wrestlers. *Arch Budo.* (2021) 17:67–74.
- Artioli GG, Gualano B, Franchini E, Scagliusi FB, Takesian M, Fuchs M, et al. Prevalence, magnitude, and methods of rapid weight loss among judo competitors. *Med Sci Sports Exerc.* (2010) 42:436–42. doi: 10.1249/MSS.0b013e3181ba8055
- Litsky F (1997). Wrestling: collegiate wrestling deaths raise fears about training. The New York Times. Available at: <https://www.nytimes.com/1997/12/19/sports/wrestling-collegiatewrestling-deaths-raise-fears-about-training.html>
- Villamón M, Brown D, Espartero J, Gutiérrez C. Reflexive modernization and the Disembedding of Jūdō from 1946 to the 2000 Sydney Olympics. *Int Rev Sociol Sport.* (2004) 39:139–56. doi: 10.1177/1012690204043458
- Basu O. A detailed look at the CAS and its rejection of Vinesh Phogat's petition The Quint (2024). Haryana, India: Jindal Global University.



## OPEN ACCESS

## EDITED BY

Alex Ojeda-Aravena,  
Universidad de Los Lagos, Chile

## REVIEWED BY

Simone Ciaccioni,  
Pegaso University, Italy

## \*CORRESPONDENCE

Paweł Adam Piepiora  
✉ pawel.piepiora@awf.wroc.pl

RECEIVED 10 November 2024

ACCEPTED 30 December 2024

PUBLISHED 09 January 2025

## CITATION

Piepiora PA, Jurczyk JB and Vveinhardt J  
(2025) Mental preparation of karateka for  
sports competition in kata.  
Front. Sports Act. Living 6:1525853.  
doi: 10.3389/fspor.2024.1525853

## COPYRIGHT

© 2025 Piepiora, Jurczyk and Vveinhardt. This  
is an open-access article distributed under the  
terms of the [Creative Commons Attribution  
License \(CC BY\)](#). The use, distribution or  
reproduction in other forums is permitted,  
provided the original author(s) and the  
copyright owner(s) are credited and that the  
original publication in this journal is cited, in  
accordance with accepted academic practice.  
No use, distribution or reproduction is  
permitted which does not comply with  
these terms.

# Mental preparation of karateka for sports competition in kata

Paweł Adam Piepiora<sup>1\*</sup> , Julia Barbara Jurczyk<sup>2</sup> and  
Jolita Vveinhardt<sup>3</sup>

<sup>1</sup>Faculty of Physical Education and Sports, Wrocław University of Health and Sport Sciences, Wrocław, Poland, <sup>2</sup>Faculty of Social Sciences and Humanities, Witelon State University of Applied Sciences in Legnica, Legnica, Poland, <sup>3</sup>Institute of Sport Science and Innovations, Lithuanian Sports University, Kaunas, Lithuania

Mental preparation for sports competition in karate is significant, as it is deeply embedded in the philosophical and ethical values that underpin this combat method. In practice, the mental preparation of karateka varies depending on the type of competition, for example preparation for kata (forms) and kumite (fights). Thus, this perspective offers a concise account of the authors' viewpoint on the leading mental skills required of kata competitors. It is argued that self-esteem, inner speech, imagination, visualisation, values and personality play a significant role in the development of confidence. In addressing stress, attention was directed towards the role of arousal, coping strategies, Jacobson's progressive relaxation, Schultz's autogenic training, biofeedback, schemas and scripts. Effective management of anxiety relies on the utilisation of mindfulness and desensitisation techniques. In maintaining attention, effective attention management, attention styles, the ability to filter out distractions, mantras and affirmations are significant. Conversely, practicing tasks that induce a Stroop effect can improve executive function skills. The above elements of mental preparation for kata competitors are universally applicable to all competitors in this field, yet they are not the sole elements that may be employed. Given the individual predispositions of kata competitors, other mental training techniques may also be applicable.

## KEYWORDS

combat sport, Kyokushin, martial art, Olympic karate, Shotokan

## Introduction

The twenty principles of karate, devised by Gichin Funakoshi, suggest that mental training is of greater importance than physical training (1). This implies that karate competitors, prior to engaging in the competitive aspects of kata (forms) or kumite (fights), are already engaged in a process of mental preparation to overcome their own weaknesses and limitations. The fundamental tenet of karate philosophy and ethics is the process of self-improvement. This is evidenced by research findings indicating a correlation between karate training and the development of mental abilities such as self-confidence, self-control (2), executive functions (3), aggression management (4), concentration (5), and resilience (6). A successful karateka is characterised by low levels of aggression, high levels of extraversion, a need for continuous experience and a low sense of anxiety (7). Moreover, the cultivation of selected psychological competencies yields enhanced performance outcomes. Mental resilience and self-efficacy exert a significant influence on the acquisition of specific fighting techniques (8). The emotional aspect is also important in karate (9–11). Additionally, high cognitive functioning – sustained attention and reaction time – distinguishes competitive karateka

from those engaged in other combat sports (12). Consequently, karate can be regarded as a method of combat, whereby systematic physical activity is designed to cultivate heightened concentration, stress management abilities, elevated emotional resilience and self-control skills (13).

In addition to the research reports described above, the experiences of sport psychologists working with karateka on mental preparation are of significant value. By drawing on these experiences, one may identify the key mental skills that are important for both coaches and karateka (14). Accordingly, this perspective represents a concise presentation of the authors' point of view on the ongoing mental preparation of karateka competing in kata. Based on these experiences, the key mental skills required of kata competitors have been identified, which include: building self-confidence, coping with stress, managing anxiety, maintaining focus of attention and maintenance of executive function (Figure 1). It should be noted that competing in kata is about performing sets of movements to the best of one's ability (15), with each set consisting of a series of coordinated and harmonious fighting techniques performed in set sequences and timings, representing an imaginary fight against opponents (16).

## Mental preparation of a kata competitor

### Building self-confidence

The objective of mental training in self-confidence is to attain a state of mind wherein the karateka possesses self-esteem and confidence in their ability to accomplish tasks. The athlete strives to achieve complete conviction that they possess the knowledge to perform the required actions (17). A lack of self-confidence can result in the loss of competitions or the avoidance of competition, even when the physical preparation is optimal. In developing self-confidence, the athlete's initial focus is on understanding their worth, strengths, and weaknesses, and their potential for further development. Subsequently, they engage in work on inner speech and imaginative training. In this process, the athlete has to have a clear vision of their desired sporting development. One effective exercise to facilitate this is to write a letter to oneself about one's successful future self and to maintain this vision in their sporting performance (18).

In addition, effective visualisation training engages all the senses: hearing, sight, smell, touch and taste. Furthermore, it

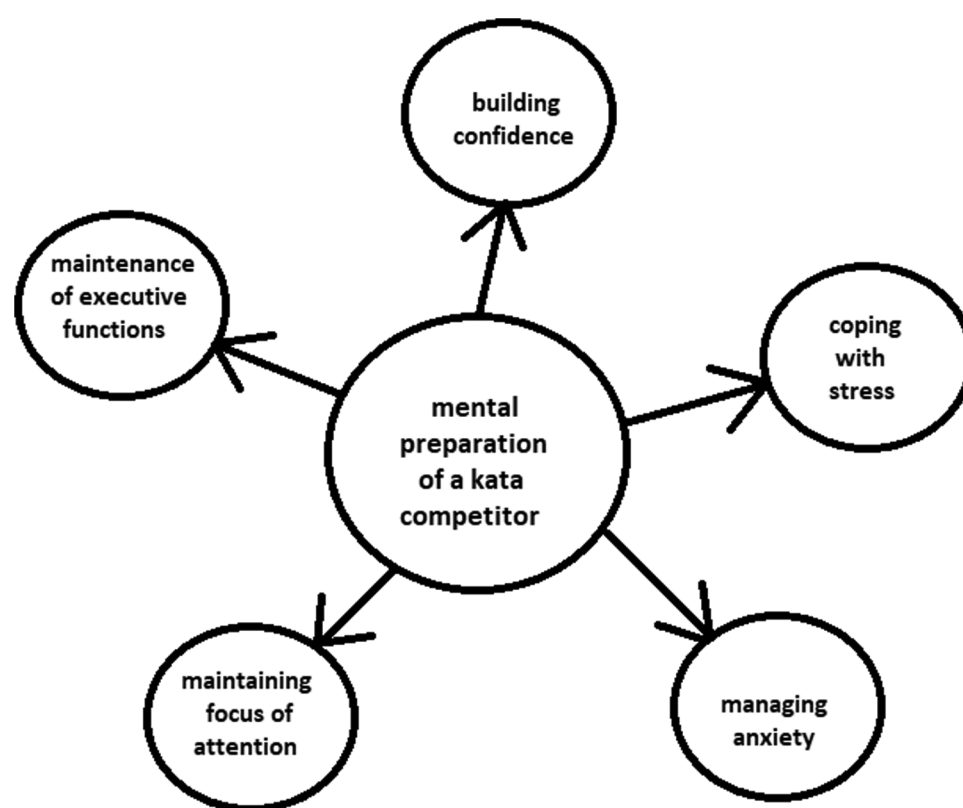


FIGURE 1  
Mental preparation of a kata competitor.

encompasses the experience of emotional states. The perspective may be external, whereby the athlete visualises themselves performing the kata, or internal, whereby the environment is seen through the eyes of the athlete. Also the angle of perception of the imagined situation can be modified (19). The size, brightness, colour of the image, the volume and pitch of the sound, and the intensity and temperature of the kinaesthetic sensations are also modified in order to select those that will result in a deep experience and the desired state. During visualisation training, the focus is on mentally repeating the karateka's starting strategies depending on the situation, with a sense of maintaining control and confidence in different situations during competition (20).

Furthermore, it is beneficial to ascertain which values are of the greatest importance to a karateka—combat sport, martial art, self-defence system—and how these can be leveraged during training and in competition to attain success (21). It is similarly important to consider the character predispositions and personality of the karateka. Once the natural functioning style of the athlete has been identified, it is essential to ascertain the extent to which their character strengths are utilised in training and competition scenarios, as well as the scope for further development (22). Additionally, an understanding of their personality profile will reveal predispositions that can enhance their effectiveness at each stage of the macro-cycle, meso-cycle and micro-cycle, as well as in situations that may be contrary to their competitive preferences (23).

An additional factor contributing to the development of self-confidence is the process of inner speech, or directed thinking. Thoughts can give rise to several risks, including mispredicting the future, misexplaining the intentions of others, or misreading situations. As a consequence, thoughts may become irrational, distorted, biased and dysfunctional (24). Consequently, thoughts may serve as a catalyst for, or a foundation of emotional and behavioural difficulties. Thus, training in the reformulation of negative thoughts must begin with the identification of such thoughts. Here, a chart can be employed, in which the athlete records their negative sports-related thoughts that occur during the day. The thoughts are attributed to the situation in which they occurred, together with emotions and behaviour. For each thought, the facts that support and contradict it are identified. Then, on the basis of the facts written out, the athlete attempts to recognise the accuracy of the thought. Subsequently, the thought must be reformulated into one that is consistent with reality, devoid of the above errors (25).

## Coping with stress

It is essential that each karateka experiences a certain degree of stress to ensure effective readiness to compete (26). Only when the threshold for achieving this readiness is exceeded, stress becomes harmful and exhausts the body (27). At the outset of working with an athlete, it is beneficial to ascertain the areas in which they experience the greatest and least stress, which may be suitable for further exploration. Such factors as the coaching

staff, rivals, training, taking part in competitions, the presence of the public at competitions, and relationships with fellow karate club members should be taken into account. Subsequently, the karateka identifies which aspects of their situation they perceive to be within their control. Stress management styles of different karateka may vary considerably and should not be imposed. These styles can be broadly categorised as task-oriented, emotion-focused, avoidance-based or will-based, and they are typically associated with specific types of stressful situations. In light of this, the sport psychologist and the athlete in question should undertake a detailed examination of the stressful situations that the athlete encounters, trying to identify and implement effective support strategies (28).

Stress is linked to a variety of physiological responses, including muscle tension, elevated heart rate and respiration, and a sensation of coldness in the extremities. By being able to influence these physiological reactions, one can counteract the negative effects of stress. Two techniques, often performed in parallel, are beneficial in managing stress and its associated physiological responses: Jacobson's progressive relaxation and Schultz's autogenic training (29). Progressive relaxation teaches the athlete to distinguish between muscle tension and relaxation, enhancing their body awareness. Autogenic training elicits the physiological responses associated with a relaxed state. In instances where the karateka is experiencing a high level of stress or a state of stress overload, the mental training regimen should be realigned with biofeedback (30). A strategy for managing stress in a competitive setting is the pre-start routine. In collaboration with the karateka, the sports psychologist develops routines and scripts comprising the scheduling of a physical and mental warm-up period, the avoidance of distractions, the regulation of time prior to the commencement of the kata, and the performance of activities that the athlete finds conducive to optimal performance (31).

## Managing anxiety

Anxiety, as a component of neuroticism, is associated with the formation of a negative cognitive representation of past or future events (32). Given the correlation between anxiety levels and a lack of focus on the present, mindfulness techniques have been demonstrated to be effective. The research results indicate that the implementation of long-term, regular mindfulness training can significantly reduce anxiety levels in athletes (33). Another efficacious technique for the management of anxiety in kata athletes is behavioural de-escalation. This involves the determination of the intensity of the stimulus, in the case of pre-competition anxiety. The work commences at an intensity level below this threshold. A given stimulus is combined with a sensation that is pleasant for the karateka, with gradual increase in intensity (34).

## Maintaining focus of attention

The concept of attention, understood as a set of interacting brain processes active during cognitive actions, plays an integral

role in mental preparation in karate (35). The processes that are of particular significance here are the capacity to actively perceive stimuli, the ability to sustain attention from the outset to the conclusion of a kata, vigilance, the selectivity of stimuli, concentration on the task at hand, the ability to switch attention between tasks, and the capacity to control attention between tasks (36). Furthermore, attention can be classified into distinct styles. These include broad and narrow external attention, as well as broad and narrow internal attention. Training in external wide attention enables the karateka to adeptly discern the various stimuli present in their environment, whereas external narrow attention facilitates the concentration on a selected aspect (37). Consequently, internal attention is manifested in the capacity to create analyses and strategies based on experience, and to discern one's own thoughts and feelings before and during the execution of movements, is contingent upon the combination of internal and external attention. This enables the adjustment of the optimal strategy for the execution of the kata (38).

Consequently, in the mental preparation of the karateka, a series of exercises are conducted with the objective of fostering long-term focus, disregarding distractors and optimising focus for a brief period. These exercises can be integrated with physical training, during which the athlete develops the ability to focus on a single signal at a time: the athlete is required to perform kata in the presence of distractors (39). The exercises should be initiated at a level the athlete is capable of mastering. Then, the level of difficulty should be augmented by increasing the number of distractors. An efficacious technique to enhance the maintenance of attention is for the karateka to establish a set of mantras or affirmations that can be employed in instances of lapses or distractions (40).

## Maintenance of executive functions

Executive functions may be defined as the ability to transition from purposeful thinking through action to the realisation of that purpose. These abilities include planning, control, and flexibility of action, initiative, self-regulation and inhibition of reactions, and insight (3). From the perspective of karate competition, all of these competencies are of equal importance in the mental preparation of the kata competitor. They can be exercised through tasks that require switching from one principle or reaction to another, tasks that present a conflict with the possibility of interference from instructions, tasks that require the inhibition of reflexive reactions, or tasks that aim to solve complex problems (41). Additionally, tasks based on the Stroop Effect, which measure reaction time in the presence of name and colour interference, have also been shown to be effective (42).

## Discussion

The modern sport psychology provides many methodologies, techniques, instruments, and resources for working with athletes. This enables the identification of the constituent elements of

mental preparation for a given sport discipline, and for a specific sport competition. However, the role of a mental coach and sport psychologist differs somewhat, as it is contingent upon the competencies that are legally permitted (43).

A mental coach works with athletes who function well in society and can apply the skills and strategies they have developed in a competitive sporting environment to other areas of their lives. In this case, the work of the mental coach involves the systematic training of the mental faculties of karateka, aiming at developing their potential, self-confidence, sense of fulfilment and satisfaction (44). The mental coach's work is oriented towards the present and the future, with the objective of enhancing the karateka's inner potential and improving their resources. It is also a partnership-based collaboration (45). A sport psychologist, conversely, possesses the competencies of both a mental coach and a psychologist, and is bound by ethical standards. She is therefore engaged in the provision of mental training, diagnosis, counselling and intervention services to athletes. In addition to mental preparation, the sport psychologist provides support in daily functioning in sport and personal life, applying methodologies from psychology (46). Furthermore, the sport psychologist may also be involved in training for karate coaches and referees and in research in this area. In contrast to a mental coach, a sport psychologist also works with athletes who are experiencing mental health difficulties (47). In such cases, working with karateka addresses their resistance, emotional suffering, dysfunction and working through past traumatic experiences. In recent years, a new specialisation in this field, clinical sport psychology, has been established (48).

In light of the aforementioned issues, the behaviour, personality and intelligence quotient of a kata competitor should be verified through an interview at the outset of their involvement and further verification should be conducted through psychological assessment and interview. However, these measures are the competence of a sports psychologist, who can then effectively determine the individual predispositions of the kata competitor—their needs and potential. In this regard, a sports psychologist is at an advantage over the mental coach, who is constrained to interviews and non-psychological tests, as their availability is not limited to experts in the field (49). The mental preparation of the kata competitor begins at the initial level and progresses to increasingly challenging tasks, facilitating a learning effect (50). At a more advanced stage of mental skill mastery, physical training should be integrated with mental training. This comprehensive approach to psycho-physical preparation reflects competitive situations and considers the distinctive aspects of kata competition (51).

## Practical recommendations

Abstracting from undertaking crisis intervention and providing psychological assistance, which are specific only to sports psychologists, practical recommendations for mental preparation are provided. A mental coach or a sport psychologist preparing a kata competitor for a sporting competition must possess a



comprehensive understanding of karate as a sport, including an in-depth knowledge of the specifics of kata competition. Mental preparation is an ongoing process. This indicates that the mental coach or a sports psychologist should collaborate with the athlete throughout the macro-cycle. Mental preparation for a kata competitor should commence several weeks prior to the planned macro-cycle. This allows for a comprehensive assessment of the competitor's abilities and potential in a controlled and non-pressurised environment. The focus of the mental preparation will be distributed throughout the macro-cycle in consideration of the scheduled competitions, the psycho-physical availability of the athlete, and the monitoring of their performance. It is also crucial for the mental coach or sports psychologist to be able to collaborate effectively with the training staff. In a professional team, this comprises a coach, a technical coach, a motor preparation coach, a physiotherapist, a doctor, a physiologist, a nutritionist, a statistical analyst and a manager. Also, professional experience within a sporting environment plays a significant role in the work of a mental coach or sports psychologist.

It is therefore recommended that the experience of a mental coach or sports psychologist from other sports be employed in the mental preparation of a kata competitor. This is a positive value in favour of the mental coach or sport psychologist, as it increases their ability to conduct mental preparation. The final point to be addressed is the obtaining of voluntary consent from the kata athlete for mental preparation. Without this, it is impossible to implement the process described in this article. At the same time, it should be noted that a mental coach is hired only for mental preparation. And a sports psychologist is recommended for broader work with a karateka, beyond mental preparation. Nevertheless, there are also cases of kata athletes forming their psychological skills solely with a karate coach.

## Limitations of the perspective

This perspective is the first article on the mental preparation of kata athletes. Yet, the derived regularities are based on the experience of the Polish karate environment, in which most of the karateka are associated with Olympic karate, Kyokushin and Shotokan styles.

## Conclusions

The presented mental preparation is universal for all kata competitors. However, their individual predispositions may translate into the use of other mental training techniques. Therefore, further research explorations are advisable.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Author contributions

PP: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. JJ: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. JV: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

## References

- Funakoshi G. *The Twenty Guiding Principles of Karate: The Spiritual Legacy of the Master*. Tokyo: Kodansha International (2013).
- Konzak B, Boudreau F. Martial arts training and mental health: an exercise in self-help. *Canada's Mental Health*. (1984) 32(4):2–8.
- Lima RF, Da Silva VF, De Oliveira GL, De Oliveira TAP, Filho JF, Mendonça JGR, et al. Practicing karate may improves executive functions of 8–11-year-old schoolchildren. *J Phys Educ Sport*. (2017) 17(4):2513–8. doi: 10.7752/jpes.2017.04283
- Misojić M, Savović B, Radenović S, Marković M. Sports activities of pupils in the function of preventing aggressive behavior. *Phys Cult Fiz Kult*. (2022) 76(2):117–28. doi: 10.5937/fizku76-44980
- Adler UB. *Karate and Mental Health: Can the Practice of a Martial art Reduce Aggressive Tendencies?* New York, NY: ETD Collection for Pace University (2003). AAI3080475. Available online at: <https://digitalcommons.pace.edu/dissertations/AAI3080475>
- Sivan A, Zeba KHF. Resilience and life satisfaction among karate and kalaripayattu practitioners. *J Psychosoc Res*. (2023) 18(1):59–69. doi: 10.32381/JPR.2023.18.01.7
- Piepiora P, Witkowski K, Piepiora Z. Personality profiles of karate masters practising different kumite styles. *Arch Budo*. (2018) 14:247–57.
- Khodabandelou M, Salehian MH. The effect of psychological toughness and self-efficacy in the acquisition of the martial arts leg kick skill. *Ido Mov Cult J Martial Arts Anthropol*. (2023) 23(2):6–12. doi: 10.14589/ido.23.2.2
- Cerin E, Barnett A. Predictors of pre- and post-competition affective states in male martial artists: a multilevel interactional approach. *Scand J Med Sci Sports*. (2011) 21(1):137–50. doi: 10.1111/j.1600-0838.2009.01006.x
- Piskorska E, Mieszkowski J, Kochanowicz A, Wędrowska E, Niespodziński B, Borkowska A. Mental skills in combat sports—review of methods anxiety evaluation. *Arch Budo*. (2016) 12:301–13.
- Fernández MM, Brito CJ, Miarka B, Díaz-de-Durana AL. Anxiety and emotional intelligence: comparisons between combat sports, gender and levels using the trait meta-mood scale and the inventory of situations and anxiety response. *Front Psychol*. (2020) 11:130. doi: 10.3389/fpsyg.2020.00130
- Grushko A, Bochaver K, Shishkina A, Kabanov D, Konstantinova M, Vavaev A, et al. Psychological and psychophysiological profile in combat sports. *Rev Artes Marciales Asiát*. (2016) 11(2):70. doi: 10.18002/rama.v11i2s.4176
- Yadav P. Harnessing the potential of karate: essential in the modern world. *Int J Res Anal Rev*. (2023) 10(4):341–4. doi: 10.56975/19sm2964
- Ciacconi S, Castro O, Bahrami F, Tomporowski PD, Capranica L, Biddle SJH, et al. Martial arts, combat sports, and mental health in adults: a systematic review. *Psychol Sport Exerc*. (2024) 70:102556. doi: 10.1016/j.psychsport.2023.102556
- Bagińska J, Piepiora P, Piepiora Z, Witkowski K. The geography of Olympic combat sports—part one: judo, karate, taekwondo. *Arch Budo*. (2022) 18:183–92.
- Vveinhardt J, Kaspere M. The relationship between mindfulness practices and the psychological state and performance of Kyokushin karate athletes. *Int J Environ Res Public Health*. (2022) 19:4001. doi: 10.3390/ijerph19074001
- Piepiora PA. *Kompendium Karate*. Wrocław: Akademia Wychowania Fizycznego we Wrocławiu (2021).
- Naranowicz M, Jankowiak K, Behnke M. Native and non-native language contexts differently modulate mood-driven electrodermal activity. *Sci Rep*. (2022) 12:22361. doi: 10.1038/s41598-022-27064-3
- Piepiora P, Witkowski K. Visualization vs. Imagery in mental training. *Arch Budo Sci Martial Arts Extreme Sports*. (2023) 19:1–4.
- Hardy L, Callow N. Efficacy of external and internal visual imagery perspectives for the enhancement of performance on tasks in which form is important. *J Sport Exerc Psychol*. (1999) 21(2):95–112. doi: 10.1123/jsep.21.2.95
- Cieciuch J, Schwartz SH. Pomiar wartości w kolowym modelu schwartza. In: Gasiul H, editor. *Metody Badania Emocji I Motywacji*. Warszawa: Difin (2018). p. 307–34.
- Park N, Peterson C, Seligman MEP. Strengths of character and well-being. *J Soc Clin Psychol*. (2004) 23(5):603–19. doi: 10.1521/jscp.23.5.603.50748
- Piepiora PA, Čaplová P, Zimoň P, Gumienna R. On research into the relationship between personality traits and the sporting level of competitive, professional and elite athletes. *Front Psychol*. (2024) 15:1428107. doi: 10.3389/fpsyg.2024.1428107
- Grishchenko G. Influence of inner speech to emotional stress in athletes. *Eur Hum Stud State Soc*. (2015) 7(3):41–50. doi: 10.38014/ehs-ss.2015.3.04
- Kreiner H, Eviatar Z. The sound of thought: form matters—the prosody of inner speech. *Phys Life Rev*. (2024) 51:231–42. doi: 10.1016/j.plprev.2024.10.006
- Ciacconi S, Martusciello F, Di Credico A, Guidotti F, Conte D, Palumbo F, et al. Stress-related hormonal and psychological changes to simulated and official judo black belt examination in older tori and adult uke: an exploratory observational study. *Sports*. (2024) 12:310. doi: 10.3390/sports12110310
- Mathew AG. Emotional intelligence and academic stress in psychology and non-psychology students. *Int J Indian Psychol*. (2023) 11(3):110–7. doi: 10.25215/1103.361
- Endler NS, Parker JD. Multidimensional assessment of coping: a critical evaluation. *J Pers Soc Psychol*. (1990) 58(5):844–54. doi: 10.1037/0022-3514.58.5.844
- Grosu VT, Popovici C, Dumitrescu M, Grosu EF. Expression of sensory submodalities by neurolinguistic programming methods in sport training. *Palestrica Third Millenn Civ Sport*. (2014) 15(3):233–7.
- Çelik E, Sarı İ. Biofeedback: its function, effects on organism and utility in sports sciences. *Turk J Sports Med*. (2022) 57(2):108–16. doi: 10.47447/tjsm.0566
- Romaniuk V, Fedorchuk S. Fight or flight mechanism and sports activities: psychophysiological aspects. *Eur Psychiatry*. (2023) 66(S1):S622. doi: 10.1192/j.eurpsy.2023.1294
- Francin-Gallego M, Oviedo-Caro MÁ, Sitko S, Legaz-Arrese A, Pano-Rodriguez A, Munguía-Izquierdo D, et al. Physical activity and anxiety in the adolescence: special emphasis on sport type and performance level. *J Public Health*. (2024). doi: 10.1007/s10389-024-02358-0
- Mojtahe K, Ali U, Ahmad MT. Examining the effects of mindfulness training on stress and anxiety in sport. *J Sport Psychol/Rev Psicol Del Deporte*. (2023) 32(2):106–14.
- Budnik-Przybylska D, Przybylski J. Trening mentalny pomocą w rehabilitacji po operacji—studium przypadku (mental training in rehabilitation after surgery—case report). *J Educ Health Sport*. (2016) 6(12):400–11. doi: 10.5281/zenodo.203310
- Dwojaczny B, Bejtka M, Iermakov S, Potop V, Yermakova T, Cieśliska M. Effects of karate training on cognitive functions in young athletes. *J Phys Educ Sport*. (2021) 21(5):2473–9. doi: 10.7752/jpes.2021.05333
- Petersen SE, Posner MI. The attention system of the human brain: 20 years after. *Annu Rev Neurosci*. (2012) 35:73–89. doi: 10.1146/annurev-neuro-062111-150525
- Gülsoy H, Erhan SE. An examination of the attention and psychological skill levels of combat athletes. *Avrasya Spor Bilimleri ve Eğitim Dergisi*. (2024) 6(2):316–32. doi: 10.47778/ejsse.1530549
- Teng Y, Wu H, Zhou X, Li F, Dong Z, Wang H, et al. Neuropsychological impact of Sanda training on athlete attention performance. *Front Psychol*. (2024) 15:1400835. doi: 10.3389/fpsyg.2024.1400835
- Iorga V, De Hillerin P-J, Rosu D, Camenidis CM, Geanta VA. The impact of psycho-neuro-motor exercises on enhancing karate technical proficiency. *J Phys Educ Sport*. (2024) 24(4):992–1000. doi: 10.7752/jpes.2024.04113
- Greco G, de Ronzi R. Effect of Karate training on social, emotional, and executive functioning in children with autism spectrum disorder. *J Phys Educ Sport*. (2020) 20(4):1637–45. doi: 10.7752/jpes.2020.04223
- Al-dabaibeh AM, Abu Ghazal MM, Ghbari TA. The effect of a training program in executive functions based on Anderson's model in reducing cognitive test anxiety. *Health Psychol Rep*. (2024). doi: 10.5114/hpr/191089
- Nanay B. The stroop effect and mental imagery. *Perception*. (2024) 53(1):61–7. doi: 10.1177/03010066231212152
- Taylor J. *Train Your Mind for Athletic Success: Mental Preparation to Achieve Your Sports Goals*. Lanham: Rowman & Littlefield (2017).
- White J, Bagnall A-M, Trigwell J. Health trainers making a difference to mental health and wellbeing. *Perspect Public Health*. (2015) 135(3):130–2. doi: 10.1177/1757913915579131
- Liew GC, Kuan G, Chin NS, Hashim HA. Mental toughness in sport. *Ger J Exerc Sport Res*. (2019) 49:381–94. doi: 10.1007/s12662-019-00603-3
- Bianco AG, Madson SK, Vealey RS, Zakrajsek RA. National collegiate athletic association athletic Trainers', Head oaches', and Student-Athletes' perceptions of professional titles used in sport psychology. *J Adv Sport Psychol Res*. (2024) 4(2):20–34. doi: 10.55743/000027
- Gouttebarger V, Castaldelli-Maia JM, Gorczynski P, Hainline B, Hitchcock ME, Kerkhoffs GM, et al. Occurrence of mental health symptoms and disorders in current and former elite athletes: a systematic review and meta-analysis. *Br J Sports Med*. (2019) 53:700–6. doi: 10.1136/bjsports-2019-100671
- Lundqvist C, Wig J, Scharly DP. Swedish Elite athletes' experiences of psychotherapy for mental health concerns provided by licensed psychologists and psychotherapists: a qualitative study. *BMJ Open Sport Exerc Med*. (2024) 10:e02044. doi: 10.1136/bmjsem-2024-002044
- McDougall M, Nesti M, Richardson D. The challenges of sport psychology delivery in elite and professional sport: reflections from experienced sport psychologists. *Sport Psychol*. (2015) 29:265–77. doi: 10.1123/tsp.2014-0081
- Epiney F, Wieber F, Loosli D, Znoj H, Kiselev N. Voluntary sports programs for individuals with mental health disorders: the trainer's view. *PLoS One*. (2023) 18(10):e0290404. doi: 10.1371/journal.pone.0290404
- Machida M, Otten M, Michelle TM, Vealey RS, Ward RM. Examining multidimensional sport-confidence in athletes and non-athlete sport performers. *J Sports Sci*. (2017) 35:410–8. doi: 10.1080/02640414.2016.1167934



## OPEN ACCESS

## EDITED BY

Alex Ojeda-Aravena,  
Universidad de Los Lagos, Chile

## REVIEWED BY

Nemanja Lakicevic,  
University of Palermo, Italy  
Valdemar Štajer,  
University of Novi Sad, Serbia

## \*CORRESPONDENCE

Jacob J. Levy  
✉ jlevy4@utk.edu

RECEIVED 12 September 2024

ACCEPTED 08 January 2025

PUBLISHED 22 January 2025

## CITATION

Levy JJ and Boyd C (2025) Getting small to feel big: the psychology of weight cutting in combat sports.

Front. Sports Act. Living 7:1495612.

doi: 10.3389/fspor.2025.1495612

## COPYRIGHT

© 2025 Levy and Boyd. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

# Getting small to feel big: the psychology of weight cutting in combat sports

Jacob J. Levy\* and Christopher Boyd

Department of Psychology, University of Tennessee, Knoxville, TN, United States

This mini review explores the psychological factors associated with weight cutting practices among combat sport athletes. We overviewed combat sport athletes' extrinsic and intrinsic motivations for their sport participation and performance expectations and goals associated with weight cutting. Next, we reviewed the extant research on psychological risk factors associated with weight cutting with a particular focus on combat sport athletes' relationship with food, societal expectations concerning body image, and disordered eating. Finally, we examined how applying task-oriented strategies and Goal Attainment Theory aligns with combat sport athletes' motivation for sport participation. We called for further research into exploring how promoting gradual weight loss may promote psychological resilience with the goal of promoting healthier weight management strategies among combat sport athletes.

## KEYWORDS

rapid weight loss, martial arts, exercise motivation, body image, performance psychology

## Introduction

In combat sports, athletes often compete against opponents with shared gender, skill level, and weight class. A common practice among combat sport athletes is *weight cutting* or losing body weight in the weeks and often days leading up to the competition. Previous investigations have found 60%–80% of combat sport athletes have reported engaging in some form of weight cutting prior to competition (1), with the highest prevalence of weight cutting being found among boxers and mixed martial arts (MMA) athletes (2). Boxing and MMA typically perform weigh-ins 24–36 h prior to competition, thus allowing for some time to partially rehydrate prior to their contest. Many of these athletes engage in rapid weight loss (RWL)—losing at least 5% of their body weight, typically through drastic dehydration methods, in the days or hours leading up to the competition weigh-in (3). During this recovery time following weigh-in, many of these athletes will gain back most of the body mass lost during their weight before entering their contest—referred to as rapid weight gain (RWG). Research on the physical health risks associated with weight cutting have found that athletes who engage in RWL/RWG practices are more prone to in-competition injury and other, potentially life threatening, health problems including cardiovascular problems, stroke, concussion proneness, heat illness (including heat stroke), hormonal imbalance, and changes in insulin sensitivity [c.f., (1, 4)]. The rationale combat sport athletes often give for engaging in weight cutting practices is to gain a competitive advantage on their opponent by competing against smaller or lighter opponents (1, 5). However, a recent meta-analysis on the effects of weight cutting on performance outcomes among combat athletes found no

substantial benefit or negative effects relative to performance success (6). Thus, there appears to be a disconnect between the athlete's perception of the performance advantages of weight cutting vs. the research findings suggesting, at best, no substantial performance benefit and, at worst, potential serious health consequences. *So why do they do it?* The purpose of this mini review is to explore the psychological factors associated with weight cutting practices among combat sport athletes. Specifically, we review the motivations and goals for engaging in weight cutting, psychological risks associated with RWL/RWG and offer our perspective regarding future directions for research into promoting a more psychologically and physically healthy approaches to weight management in combat sport.

## Motivations for weight cutting

Combat sport athletes often view weight management as an essential part of their competitive strategy. For example, a combat sport athlete would rather be at the top of a lighter weight class, than the bottom of a heavier weight class (5). In terms of external sources of motivation for this practice, combat sports culture often glorifies extreme weight-cutting practices, viewing RWL as a symbol of discipline and dedication (7). These cultural norms begin early in a combat athletes' training—often in childhood—and persist throughout their athletic career (36). RWL practices are often encouraged by coaches and fellow athletes, rather than by qualified health professionals like physicians and dietitians (7). Coaches and peers, who may lack formal training in nutrition or health, frequently advocate for RWL based on anecdotal evidence rather than scientific knowledge. This reliance on non-expert advice can lead athletes to engage in RWL without fully considering potential health risks, from acute to chronic complications (8). Thus, the continuation of unhealthy practices may be associated, in part, to the desire to please or be praised by coaches and peers.

From an intrinsic motivation perspective, research suggests that combat sport athletes are often drawn to and remain in their sport because their intrinsic need for challenge, accomplishment, and competence (5, 9, 10). For female combat sport athletes, Mathisen and colleagues (11) found the desire to gain strength, learn self-defense, and feel more confident often drives women to combat sports, which are traditionally male-dominated, and challenge societal expectations of female behavior. They also highlight the inclusive and supportive community within combat sports, which fosters feelings of belonging, further contributing to empowerment. The sense of control that comes with participating in combat sports may be linked to the prevalence of weight regulation practices, as female athletes often seek to manage their bodies to meet weight class requirements and optimize performance. For both male and female combat athletes, successfully reaching weight targets can enhance motivation, self-esteem, and a sense of accomplishment, fostering positive mental health and psychological resilience

(12, 13). However, failure to meet weight goals or the absence of visible progress can lead to self-doubt, diminished mental readiness, and heightened anxiety (13).

*Horrible—but worth it* (5) is a statement combat sport athletes often offer when describing the RWL/RWG practices. Engaging in this challenging practice may be meeting their intrinsic motivational needs, as well being externally reinforced by their coach and peers. However, we posit weight cutting may also provide a built-in excuse for performance failure, which may serve the function of minimizing threats to self and self-worth. For example, a loss may be attributed to a *bad weight cut* as opposed to those that may be more personal (e.g., the other fighter was more skilled). Further research is needed to explore and clarify the relationship among these intrinsic and extrinsic motives for weight cutting practices.

## Weight cutting, body image, and cultural norms

In addition to the physical health risks associated with weight cutting practices, the process of engaging in RWL/RWG can also impact the combat sport athlete's relationship with food, disordered eating, and are linked to negative psychological outcomes including increased stress, nervousness, tension, fatigue, and anger (14, 15). Disordered eating (DE) is prevalent among combat athletes, with 83% of males and 89% of females exhibiting moderate to very high DE scores post-competition (16). The mental strain caused by weight management pressures, particularly those linked to RWL, contributes to struggles with food control, bingeing, and body dissatisfaction. The link between restrictive eating and emotional eating is another challenge for athletes. Restrained eating, common among combat athletes, can increase the likelihood of emotional eating, particularly after competitions. Barker and colleagues (17) identified that efforts to maintain dietary restraint can deplete self-control, making it harder to resist emotional eating. According to the limited capacity theory, individuals have a finite number of cognitive resources for self-control, and when these resources are depleted by the effort of regulating emotions, their ability to manage food intake may be compromised. Self-control theory posits that engaging in one self-control task, such as dietary restraint, can hinder self-control in other areas, like resisting emotional eating, especially when individuals face multiple self-control demands or feel depleted. Athletes reported a cycle of restrictive eating before competition followed by emotional eating after, particularly if they lost. This behavior aligns with theories like the boundary model of eating, which explains that restrained eaters often set strict dietary rules for themselves. When they perceive a violation of these rules, they may experience the *what-the-hell effect*, leading to overeating (17). Interventions such as emotional eating diaries, mindful eating, and alternative coping strategies can help athletes manage these challenges (17). Interestingly, while male athletes often experience declining body satisfaction post-competition, female athletes show improvements, suggesting a potential



sex-specific temporal relationship with DE (16). Regardless of sex, the severity of negative mood states appears to be directly proportional to the magnitude of weight loss within a given timeframe, indicating that more aggressive RWL methods could have greater negative impacts on athletes' mental well-being (37).

Despite the psychological risks, some athletes continue to use weight cutting to gain a competitive psychological advantage, believing that appearing leaner or lighter projects strength (13). However, the long-term emotional and psychological effects of these practices require interventions to promote healthier relationships with food and body image (16). Cultural norms and media portrayals strongly influence body image and weight management in athletes. Media-driven ideals of body types also contribute to athletes' concerns about muscularity and lead to unhealthy weight management behaviors (13, 18). For example, in collegiate wrestling, extreme weight management practices are deeply embedded in the sport's culture. This normalization reinforces the belief that weight cutting is an integral aspect of the sport, despite its physical and psychological toll (12). This normalization exacerbates body dissatisfaction and fosters unhealthy eating patterns (16), as athletes conform to the pressures of weight-class sports. Research shows that many judo athletes first engage in RWL as young as four years old, with more common onset around ages nine to twelve (19–21). This suggests that RWL/RWG is a heritage younger combat sport athletes inherit from older counterparts, who already experience the adverse effects of RWL, such as distorted self-image, negative mood profiles, impaired short-term memory, high susceptibility to eating disorders, and menstrual dysfunction (22). Coaches are identified as the primary source of information regarding RWL methods, with few athletes consulting health professionals for weight management advice. This suggests that RWL practices are passed down through tradition rather than based on evidence-based or scientifically sound approaches (23).

Fasczewski and colleagues (24) highlight male athletes, especially in weight-class sports, face intense pressure to conform to ideals of muscularity, often leading to extreme dieting and excessive exercise. This drive is reinforced by cultural norms that equate muscularity with strength and dominance, particularly in combat sports. Satterfield and Stutts (38) observe that male wrestlers frequently engage in severe weight-cutting practices to meet weight class requirements while enhancing muscle mass, reflecting the broader cultural emphasis on size and strength as markers of athletic success.

Research shows that female combat sport athletes face unique societal pressures, with higher levels of disordered eating, such as restrictive dieting and excessive exercise, compared to male athletes (16). These pressures, combined with weight-cutting practices, increase the risk of developing conditions associated with the female athlete triad—disordered eating, menstrual dysfunction, and low bone mineral density (25, 26). Prolonged exposure to these conditions can significantly harm athletes' health and shorten their competitive careers (27, 28). Moreover, the tension between maintaining a lean, feminine body ideal and the muscular physique required for combat sports leads to

heightened body dissatisfaction and extreme weight management practices (29, 30).

## Gradual weight loss approaches and psychological resilience

Combat sports often normalize RWL practices driven by the immediate pursuit of competitive advantages. However, evidence indicates that a gradual approach—defined as 0.5–1 kg per week—not only aligns better with athletes' long-term health and performance goals but also supports psychological well-being (31). Gradual weight loss preserves lean body mass and enhances performance compared to rapid weight loss methods, which can lead to detrimental effects on body composition and strength (8). Athletes who adhere to a slower rate of weight loss experience improvements in lean body mass, strength, and power-related performance, which are critical for sustaining high-level performance in combat sports. Fogelholm and colleagues (31) further demonstrate that gradual weight loss results in better muscle mechanical functioning, such as increased vertical jump height, compared to rapid methods. Additionally, Miranda and colleagues (39) highlight that gradual weight loss contributes to better maintenance of performance metrics and reduces the adverse effects often observed with rapid weight loss methods.

From a psychological perspective, resilient athletes tend to use task-oriented coping strategies, focusing on practical and proactive ways to manage challenges (32). Crust and Clough provide a clear connection between mental toughness, gradual goal-setting, and long-term resilience. By encouraging slow, deliberate weight loss, athletes can build the mental toughness necessary to handle the physical and psychological demands of competition while maintaining their well-being. Crust and Clough (32) argue that achieving long-term goals, which require significant time and dedication, can enhance self-belief and perceptions of competence—aligning with their intrinsic motivations for sport participation. The process of working towards these goals helps athletes develop resilience and mental toughness.

Gradual weight loss aligns with Goal Attainment Theory by breaking down large, long-term goals into smaller, manageable steps. This approach fosters resilience by allowing athletes to focus on incremental progress rather than short-term fixes. Resilient athletes are better at managing stress and anxiety, which are significant during weight management (33). Gradual weight loss supports task-oriented coping strategies, which focus on improving specific aspects of performance and managing stress in a controlled manner. By setting daily or weekly goals, athletes can maintain a sense of control and manage pressure effectively, reducing the overwhelming stress associated with rapid weight loss. Conversely, rapid weight loss can overwhelm athletes, leading to negative appraisals and increased anxiety, which adversely affects performance (34). Coaches and athletes should be encouraged to adopt gradual weight loss strategies to promote healthier mental states and prevent the negative psychological outcomes associated with rapid weight loss.



## Conclusion and future directions

Combat sports culture often glorifies extreme weight-cutting practices (7). This cultural norm, deeply ingrained in the sport, can overshadow the benefits of a more controlled and gradual approach to weight management. While weight regulation is culturally significant, it's essential to balance these norms with health considerations. Gradual weight loss can be framed as both a culturally acceptable and health-conscious strategy, allowing athletes to meet cultural expectations while preserving their well-being. By integrating gradual weight loss into the cultural narrative, coaches can demonstrate that maintaining health is compatible with achieving sport-specific goals, thus promoting a more sustainable and health-focused approach. This shift can enhance athletes' self-image, reduce stress, and support overall psychological resilience and health (31, 35).

Educating athletes, coaches, and support staff about the benefits of gradual weight loss and the psychological advantages associated with task-oriented coping strategies may facilitate a shift in practices and perspectives. Providing knowledge about the long-term benefits of gradual weight loss and encouraging the use of effective coping strategies—such as problem-solving and goal setting—may help athletes manage the challenges of weight cutting more effectively. Implementing gradual weight loss strategies in combat sports may offer numerous advantages, including better preservation of lean body mass, enhanced performance, and improved psychological resilience. Additional research is needed to explore the shifting cultural norms and promoting education about the benefits of gradual weight loss to foster a more supportive and effective training environment. Such a future focus may not only benefit athletes' physical health but also may also support their mental well-being, ultimately contributing to sustained success in combat sports.

## References

1. Barley OR, Chapman DW, Abbiss CR. The current state of weight cutting in combat sports. *Sports*. (2019) 7(123):1–11. doi: 10.3390/sports7050123
2. Reale R, Slater G, Burke LM. Acute-weight-loss strategies for combat sports and applications to Olympic success. *Int J Sport Physio and Perform*. (2017) 12(2):142–51. doi: 10.1123/ijspp.2016-0211
3. Artioli GG, Saunders B, Iglesias RT, Franchini E. It is time to ban rapid weight loss from combat sports. *Sport Med*. (2016) 46(11):1579–84. doi: 10.1007/s40279-016-0541-x
4. Hammer E, Sanfilippo JL, Johnson G, Hetzel S. Association of in-competition injury risk and the degree of rapid weight cutting prior to competition in division I collegiate wrestlers. *British J Sport Med*. (2023) 57(3):160–5. doi: 10.1136/bjsports-2022-105760
5. Smith KA, Naughton RJ, Langan-Evans C, Lewis K. “Horrible—but worth it”: exploring weight cutting practices, eating behaviors, and experiences of competitive female taekwon-do athletes. A mixed methods study. *J Clin Sport Psych*. (2024) 18(1):150–64. doi: 10.1123/jcsp.2021-0103
6. Brechney GC, Cannon J, Goodman SP. Effects of weight cutting on exercise performance in combat athletes: a meta-analysis. *Int J Sport Physio Perform*. (2022) 17:995–1010. doi: 10.1123/ijspp.2021-0104
7. Lakicevic N, Mani D, Paoli A, Roklicer R, Bianco A, Drid P. Weight cycling in combat sports: revisiting 25 years of scientific evidence. *BMC Sports Sci Med Rehabil*. (2021) 13:154. doi: 10.1186/s13102-021-00381-2
8. Garthe I, Raastad T, Refsnæs PE, Koivisto A, Sundgot-Borgen J. Effect of two different weight-loss rates on body composition and strength and power-related

## Author contributions

JL: Conceptualization, Writing – original draft, Writing – review & editing. CB: Writing – original draft, Writing – review & editing.

## Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. Funding for open access to this research was provided by University of Tennessee's Open Publishing Support Fund.

## Conflict of interest

The authors declare that this research review was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

## Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- performance in elite athletes. *Int J Sport Nutr Exerc Metab*. (2011) 21(2):97–104. doi: 10.1123/ijsnem.21.2.97
9. Tarver TL, Levy JJ. Brazilian Jiu Jitsu players' motivations to train. *Front Psychol*. (2023) 14:1240351. doi: 10.3389/fpsyg.2023.1240351
10. Malchrowicz-Moško E, Zarębski P, Kwiatkowski G. What triggers US to be involved in martial arts? Relationships between motivations and gender, age and training experience. *Sustainability*. (2020) 12(16):6567. doi: 10.3390/su12166567
11. Mathisen TF, Kumar RS, Svantorp-Tveiten KME, Sundgot-Borgen J. Empowered, yet vulnerable: motives for sport participation, health correlates, and experience of sexual harassment in female combat-sport athletes. *Sports*. (2022) 10(5):68. doi: 10.3390/sports10050068
12. Coker-Cranney A, Watson JC, Bernstein M, Voelker DK, Coakley J. How far is too far? Understanding identity and overconformity in collegiate wrestlers. *Qual Res Sport Exerc Health*. (2018) 10(1):92–116. doi: 10.1080/2159676X.2017.1372798
13. Pettersson S, Ekström MP, Berg CM. Practices of weight regulation among elite athletes in combat sports: a matter of mental advantage? *J Athletic Train*. (2013) 48(1):99–108. doi: 10.4085/1062-6050-48.1.04
14. Choma CW, Sforzo GA, Keller BA. Impact of rapid weight loss on cognitive function in collegiate wrestlers. *Med Sci Sport Exerc*. (1998) 30(5):746–9. doi: 10.1097/00005768-199805000-00016
15. Degoutte F, Jouanel P, Begue RJ, Colombier M, Lac G, Pequignot JM, et al. Food restriction, performance, biochemical, psychological, and endocrine changes in judo athletes. *Int J Sports Med*. (2006) 27:9–18. doi: 10.1055/s-2005-837505

16. Doherty CS, Fortington LV, Barley OR. Prevalence of disordered eating and its relationship with rapid weight loss amongst male and female combat sport competitors: a prospective study. *J Scien Med Sport*. (2024) 27(11):745–52. doi: 10.1016/j.jsams.2024.06.007
17. Barker L, Ruiz MC, Nevill A, Cloak R, Lane AM, Devonport TJ. Dietary restraint and emotional eating among elite/international combat sport athletes. *Int J Sport Exerc Psych*. (2024):1–18. doi: 10.1080/1612197X.2024.2308884
18. Peacock CA, French D, Sanders GJ, Ricci A, Stull C, Antonio J. Weight loss and competition weight in ultimate fighting championship (UFC) athletes. *J Funct Morphol Kinesiol*. (2022) 7:115. doi: 10.3390/jfmk7040115
19. Artioli GG, Gualano B, Franchini E, Scagliusi FB, Takesian M, Fuchs M, et al. Prevalence, magnitude, and methods of rapid weight loss among judo competitors. *Med Sci Sport Exerc*. (2010) 42(3):436–42. doi: 10.1249/MSS.0b013e3181ba8055
20. Berkovich B, Eliakim A, Nemet D, Stark AH, Sinai T. Rapid weight loss among adolescents participating in competitive judo. *Int J Sport Nutri Exerc Metab*. (2016) 26(3):276–84. doi: 10.1123/ijsnem.2015-0196
21. Štangar M, Štangar A, Šhtyrba V, Cigić B, Benedik E. Rapid weight loss among elite-level judo athletes: methods and nutrition in relation to competition performance. *J Int Soc Sport Nutri*. (2022) 19(1):380–96. doi: 10.1080/15502783.2022.2099231
22. Burke LM, Slater GJ, Matthews JJ, Langan-Evans C, Horswill CA. ACSM expert consensus statement on weight loss in weight-category sports. *Cur Sport Med Repor*. (2021) 20(4):199–217. doi: 10.1249/JSR.0000000000000831
23. Lakicevic N, Matthews JJ, Artioli GG, Paoli A, Roklicer R, Trivic T, et al. Patterns of weight cycling in youth Olympic combat sports: a systematic review. *J Eating Disord*. (2022) 10:75. doi: 10.1186/s40337-022-00595-w
24. Faszczewski KS, Powell SM, Stevens NR, Skinner JW. “Strong, fearless, tough, enduring”: collegiate male wrestlers’ perceptions of body image and masculinity. *Perform Enhance Health*. (2022) 10(1):100212. doi: 10.1016/j.peh.2021.100212
25. Mountjoy M, Sundgot-Borgen JK, Burke LM, Ackerman KE, Blauwet C, Constantini N, et al. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sport Med*. (2018) 28(4):316–31. doi: 10.1136/bjsports-2018-099193
26. Warrick A, Faustin M, Waite B. Correction to: comparison of female athlete triad (triad) and relative energy deficiency in sport (red-S): a review of low energy availability, multidisciplinary awareness, screening tools and education. *Cur Phys Med Rehab Report*. (2020) 8(4):385. doi: 10.1007/s4041-020-00303-2
27. Byrne S, McLean N. Elite athletes: effects of the pressure to be thin. *J Sci Med Sport*. (2002) 5(2):80–94. doi: 10.1016/S1440-2440(02)80029-9
28. Kwiatkowska-Pamuła A, Kurylas A, Perenc A, Ziółko E, Zlotkowska R, Muc-Wierżgoń M. Assessment of nutrition in female judokas during the precompetitive body mass reduction period. *Trends Sport Sci*. (2017) 4(24):183–7. doi: 10.23829/TSS.2017.24.4-6
29. Langan-Evans C, Cronin C, Hearnis MA, Elliott-Sale KJ, Morton JP. Perceptions of current issues in female sport nutrition from elite athletes, practitioners, and researchers. *Women Sport Phys Act J*. (2022) 30(2):133–43. doi: 10.1123/wspaj.2022-0004
30. Viveiros L, Moreira A, Zourdos MC, Aoki MS, Capitani CD. Pattern of weight loss of young female and male wrestlers. *J Strength Cond Res*. (2015) 29(11):3149–55. doi: 10.1519/JSC.0000000000000968
31. Fogelholm GM, Koskinen R, Laakso J, Rankinen T, Ruokonen I. Gradual and rapid weight loss. *Med Sci Sport Exerc*. (1993) 25(3):371–7. doi: 10.1249/00005768-199303000-00012
32. Crust L, Clough PJ. Developing mental toughness: from research to practice. *J Sport Psych Action*. (2011) 2(1):21–32. doi: 10.1080/21520704.2011.563436
33. Secades XG, Molinero O, Salguero A, Barquin RR, de la Vega R, Márquez S. Relationship between resilience and coping strategies in competitive sport. *Percept Mot Skills*. (2016) 122(1):336–49. doi: 10.1177/0031512516631056
34. Gonçalves S, Ribeiro A, Félix S, Gomes AR. Does weight change relate to psychological variables and eating behaviours in combat sports? *Eat Weight Disord*. (2021) 26(3):921–30. doi: 10.1007/s40519-020-00933-4
35. Litwic-Kaminska K. Types of cognitive appraisal and undertaken coping strategies during sport competitions. *Int J Environ Res Public Health*. (2020) 17(18):6522. doi: 10.3390/ijerph17186522
36. Noonan-Holohan S, Cullen SJ, Dunne A, Warrington G, Fitzpatrick P, Pugh J, et al. The behavioural determinants of weight-making in weight-category sports: a narrative review. *Perform Enhance Health*. (2024) 12(1):100273. doi: 10.1016/j.peh.2024.100273
37. Lakicevic N, Thomas E, Isacco L, Tcymbal A, Pettersson S, Roklicer R, et al. Rapid weight loss and mood states in judo athletes: a systemic review. *Euro Rev Appl Psych*. (2024) 74(4):100933. doi: 10.1016/j.erap.2023.100933
38. Satterfield NA, Stutts LA. Pinning down the problems and influences: disordered eating body satisfaction in male wrestlers. *Psych Sport Exerc*. (2021) 54:101884. doi: 10.1016/j.psychsport.2021.101884
39. Miranda KA, Gheller RG, Da Silva IM, Picanço LA, Dos Santos JO. Effects of gradual weight loss on strength levels and body composition in wrestlers athletes. *J Sport Med Phys Fitness*. (2021) 61(3):401–6. doi: 10.23736/s0022-4707.20.11254-4

# Frontiers in Sports and Active Living

Stepping up our understanding of sport and physical activity

A multidisciplinary journal which investigates all aspects of sports, physical activity, and active living to understand the benefits and risks of non-sedentary behavior.

## Discover the latest Research Topics

[See more →](#)

### Frontiers

Avenue du Tribunal-Fédéral 34  
1005 Lausanne, Switzerland  
[frontiersin.org](https://frontiersin.org)

### Contact us

+41 (0)21 510 17 00  
[frontiersin.org/about/contact](https://frontiersin.org/about/contact)



### Frontiers in Sports and Active Living

