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| Physiological training in striking combat sports: A protocol for a systematic review |  | For correspondence: adam.kirkwood2@stu.mmu.ac.uk  |

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# ABSTRACT

**Introduction:** Physiological training can be used to improve the capacity and efficiency of the body’s internal energy systems.The capability of the three energy systems; 1) adenosine triphosphate and phosphocreatine (ATP-PCr) 2) glycolytic 3) oxidative, can distinguish between lower- and higher-level combat sport athletes. Therefore, physiological training is of great importance for athlete’s wishing to improve athletic performance. However, no study has reviewed the scientific literature regarding physiological training programmes for striking combat sports, such as boxing, kickboxing, karate, muay Thai or taekwondo. Therefore, the objective of this review is to synthesise the literature on the effectiveness of physiological training programmes in striking combat sports.

Alongside tactical, technical and strength development, physiological development is a key factor in success for combat sport athletes. Literature around striking combat sport physiology is an area that has been monitored in multiple ways across boxing, karate, kickboxing, muay Thai and taekwondo. However, reviews in this area for coaches and practitioners with the desire to optimise physiological training for their fighters has not yet been produced. The objective of this review is to analyse the extent to which physiological training can develop fighter physiology in striking combat sports, to allow coaches and researchers to better understand how to optimise performance through training.

**Methods:** The review will be conducted in accordance with the Joanna Briggs Institute (JBI) and reported according to Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines. Four databases (PubMed, Scopus, SPORTDiscus and Web of Science) will be searched. Two reviewers will independently screen the title and abstracts, before assessing the full text of the remaining articles. The relevant data will be extracted and presented in tables.

**Dissemination:** The systematic review will summarise the available literature that analyses physiological training in striking combat sports, with the findings used to direct future combat sport conditioning training and research. The authors aim to publish the review in a peer-reviewed journal and present the findings at a relevant conference.

# 1.0 INTRODUCTION

## 1.1 Background

Combat sports are a class of contact sports in which two opponents engage in one-to-one competition with the specific ruleset determined by the specific sport (Barley, Chapman and Abbiss, 2019). Typically, combat sports consist of dynamic, high intensity movements interspersed with active or passive recovery, where success is usually achieved by powerful actions applied unpredictably (Matsugishe et al, 2011). This century has seen a large increase in the popularity of combat sports, through increased media focus, revenue, and sponsorship, with some of the world’s most popular athletes participating in various combat sports (Dziubiński, 2024).

Combat sports can be characterised as grappling, striking or mixed combat sports (James et al, 2016), however this review will focus solely on striking combat sports, including boxing, karate, kickboxing, muay Thai and taekwondo. Despite technical and tactical differences between these sports, the movement patterns and motions incorporate similar energy system utilisation (Lahart and Robertson, 2009). Striking combat sports incorporate skills such as kicks, punches, elbows and knees aimed at various sections of the opponent including the head, torso and legs (Rodrigues-Silva et al, 2011). Striking combat sports with minimal grappling were included due to the different physiological requirements to repeatedly execute strikes when compared with grappling-style sports. It is important to understand how physiological training can be used to improve striking combat sports specifically.

Physiological training can incorporate a range of exercise modalities used to develop various systems within the body, including the ATP-PCr, glycolytic and oxidative systems (Snyder, 2024). These systems are vital in combat sports to facilitate the dynamic and intermittent movements associated with the sports, repeatedly over several rounds of a fight, with some sports having athletes fight multiple times per day (Baker et al, 2010). Physiological training affects the fighter in many ways such as mitochondrial biogenesis, where repeated training can increase the number and surface area of mitochondria, increasing the rate at which adenosine triphosphate can be produced in the body (Hood, 2009). Physiological training can also increase the amount of glycogen stored in the muscles – as the primary fuel source for high intensity exercise, having a large store of muscle glycogen is vital to enable fighters to repeat the high intensity movements such as kicking, over a long period of time (Bergström and Hultman, 1967). Whilst other adaptations to energy systems induced by exercise training are contributors, mitochondrial biogenesis and increased muscle glycogen stores are two of the main factors in physical capacity (Bartlett et al, 2013).

Previous literature has examined several forms of physiological training across boxing, karate, kickboxing, muay Thai and taekwondo, using multiple types of studies and durations of training. This review will synthesize the data from relevant studies to provide an overview of how energy system training can develop fighter metabolic regulation in striking combat sports.

## 1.2 Objective

The objective of this review is to analyse the extent to which physiological training can develop key outcome variables (e.g. V̇O2max) in striking combat sports, to allow coaches and researchers to better understand how to optimise performance through training.

## 1.3 Review question

To what extent does physiological training develop physiological outcome variables in striking combat sports?

# 2.0 METHODS

The systematic review will be conducted in accordance with the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis (Aromataris et al., 2024) and reported using the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines (Page et al., 2020).

## 2.1 Inclusion criteria

The population, intervention, comparison, and outcome (PICO) framework will be used to categorise the inclusion criteria, as recommended in the PRISMA guidelines for systematic reviews by Page et al (2020).

## 2.1.1 Population

The population of interest is any healthy boxing, karate, kickboxing, muay Thai or taekwondo athlete (tier 2 and above, McKay et al, 2022) aged 16-40 years.

## 2.1.2 Intervention

Any physical training intervention that targets physiological development and is equal to or greater than two weeks long and no longer than twelve weeks. Two weeks was selected as the minimum duration due to previous research showing physiological development after this period of time (Jeukendrup et al, 1992). Twelve weeks was selected as the maximum period of time due to it typically reflecting three mesocycles usually observed in a build-up to a major competition. Studies that only investigate muscular strength training will not be included, however those that include both physiological and muscular strength training will be considered. Studies using only a sport as the intervention, and studies including the use of ergogenic aids, will not be included.

## 2.1.3 Comparison

Comparisons will be made between pre- and post-intervention tests of physical capacity.

## 2.1.4 Outcome

The outcomes from the studies will be the results of the physiological tests, such as V̇O2max. Validated sport-specific tests will be included in the review, as well as more common validated tests such as an incremental cycling test.

## 2.2 Search strategy

The systematic review will contain studies extracted using the relevant search strategy from four databases – PubMed, Scopus, SPORTDiscus and Web of Science. The search terms will be altered for each database depending on individual differences within the programming of the database. Where possible, all terms will be searched within title and abstract, and where this is not possible, the abstract will be searched. Additional filters added to the search strategy will be human population, with studies in English, and peer-reviewed journal articles, where possible in each database. The date range will be compressed to 2000-present. This range was decided for multiple reasons relating to the increase in combat sport literature at the beginning of the date range. The reference list of all eligible sources of evidence will be screened for studies that fit the search criteria but were not displayed on the relevant databases.

**Table 1. Search terms**

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| Population | boxing or boxer\* or karate\* or kickbox\* or “muay thai” or taekwondo or “combat sport\*” |
| Intervention | phys\* or aerobic or anaerobic or alactic or “energy system\*” or HIIT or HIT or “high intensity interval training” or “high intensity training” or fitness or sprint or interval or fartlek or “steady state” or kick\* or conditioning or continuous or training or battery or punch\* or strik\* or program\* or exercise\* or train\* or fight\* or spar\* or ATP or glycolytic or oxidative |
| Comparison | baseline or “baseline test\*” or initial or develop\* or improv\* or differen\* or benefit\* or compar\* or result\* or experience\* or adapt\* or outcome\* |
| Outcome | phys\* or test\* or “heart rate\*” or V̇O2 or V̇O2max or V̇O2peak or oxygen\* or volume or aerobic or “aerobic capacity” or anaerobic or “anaerobic capacity” or alactic or “alactic capacity” or “alactic power” or increment\* or interval\* or intensity or duration or frequency or “revolutions per minute” or RPM or bike or treadmill or ergometer or “sport specific” or specific\* or combat\* or sport\* or maxim\* or exhaust\* or peak\* or zone\* or perform\* or watt\* or “maximal oxygen uptake” |

\* indicates a search term that can have any ending.

## 2.3 Study selection

The searches will be exported from each database and imported into the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia), where all duplicate studies will be removed from the bank of literature. Only primary original articles will be included in the review. The titles and abstracts will be screened independently by two reviewers (AK and DR) against the inclusion criteria. The next stage will involve the same two reviewers assessing the full text of the remaining articles, where the reason for exclusion will be reported in a flow diagram within the systematic review. If any abstracts are selected without the full text available, the authors will be contacted with a request to obtain the full text. Authors will be given ten working days to respond, and if no response is received a follow-up contact will be sent. If no response is received within five working days, the study will be excluded from review and the reason will be noted and displayed in the flow diagram. Any disagreements between reviewers at any stage of study selection will be resolved by another independent reviewer (GS).

## 2.4 Data extraction

The studies selected for the systematic review will undergo data extraction by the two reviewers (AK and DR). The data extracted is outlined below in Table 2.

**Table 2. Data extraction**

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| **Subcategory** | **Data extracted** |
| General information | TitleAuthorsYear of publicationJournalSport |
| Methods | Sample sizeParticipant characteristics e.g., age, gender, body massLevel of athlete, e.g. tier 2 and above (McKay et al., 2022)Experience within sport, e.g. years of trainingStudy design |
| Training programmeOutcome | Training programme durationTests completedTraining time per weekTraining modalityProgramme details e.g., intensity, volume, etc.Pre- and post-results |

## 2.5 Risk of bias analysis

As recommended in the PRISMA guidelines for systematic reviews (Page et al, 2020), a risk of bias analysis will be conducted. A modified Downs and Black checklist (Downs and Black, 1998) will be used as it is a validated and extensively used tool for assessing the risk of bias in physical intervention studies.

## 2.6 Data synthesis and presentation

The subcategories described in Table 2 will be presented in a table containing the key data from each extracted study.

# Contributions

Contributed to conception and design: AK, GS, LB, DR

Drafted and/or revised the article: AK, GS, LB, DR

Approved the submitted version for publication: AK, GS, LB, DR

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# Conflicts of interest/Competing interests

All authors declare no conflicts of interest or competing interests related to this study.

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