

**Ultimate Full Contact WUFC World  
Championship – technical and tactical  
performance analysis through observation of  
competitive performance**

**Fernando Casimiro Loio Pinto**

Tese para obtenção do Grau de Doutor em  
**Ciências do Desporto**  
(3<sup>o</sup> ciclo de estudos)

Orientador: Prof. Doutor Ricardo Manuel Pires Ferraz  
Co-orientador: Prof. Doutor Henrique Pereira Neiva

**julho 2021**



**Provas públicas de defesa de Doutoramento realizadas a 15 de julho de 2021 na Universidade da Beira Interior, Covilhã, Portugal**

**Presidente do Júri:**

Professor Doutor Joaquim Mateus Paulo Serra

**Arguentes:**

Professora Doutora Isabel Maria Ribeiro Mesquita

Professora Doutora Ágata Cristina Marques Aranha

Professor Doutor Daniel Almeida Marinho

Professor Doutor Fernando Paulo Sebastião Rocha

Professor Doutor Ricardo Manuel Pires Ferraz



*In memory of my dear mother  
Maria Rosa Ramos Casimiro Loio Pinto*

Academic thesis submitted with the purpose of obtaining a doctoral degree in Sport Sciences according to the provisions of Portuguese Decree-Law 107/2008 of 25 June.



# **Acknowledgments**

My profound gratefulness to all teaching staff of the Department Sport Sciences, University of Beira Interior for their knowledge and support, especially to Professor Ricardo Ferraz and Professor Henrique Neiva. A special thanks to my family, my wife, and daughters (Maria Amélia, Ana Raquel, Diana Isabel e Susana Maria) for the constant encouragement and support. I would also like to thank the WUFC World Ultimate Full Contact – Association for its support.



# List of Publications

This Doctoral Thesis is Supported by the following papers:

- **Loio, F.**, Neiva, H., Nunes, C., Branquinho, L., Ferraz, R. (2021). Theoretical basis of technical-tactical behavior and its application in Ultimate Full Contact training. *The Open Sports Sciences Journal*. 14, 9-13. doi: 10.2174/1875399X02114010009
- **Loio, F.**, Neiva, H., Nunes, C., Branquinho, L., Ferraz, R. (2020). Ultimate Full Contact offensive efficiency analyzed through styles and combat distances: a confluence of cognitive and ecological approaches. *Archives of Budo Science of Martial Arts and Extreme Sports*. 16. Available online: <http://smaes.archbudo.com/view/abstract/id/13785>
- **Loio, F.**, Neiva, H., Nunes, C., Branquinho, L., Ferraz, R. (2020). Anticipated, Simultaneous and Posterior Counter-Attack Efficiency in Ultimate Full Contact. *Archives of Budo Science of Martial Arts and Extreme Sports*. 16. Available online: <http://smaes.archbudo.com/view/abstract/id/13783>
- **Loio, F.**, Neiva, H., Nunes, C., Branquinho, L., Ferraz, R. (2020). Ultimate Full Contact: defensive efficiency and ground fighting control, interrelating the different technical-tactical skills. *Archives of Budo Science of Martial Arts and Extreme Sports*.
- **Loio, F.**, Neiva, H., Nunes, C., Marques, M.C., Sousa, A., Marinho, D.A., Branquinho, L., Ferraz, R. (2020). Ultimate Full Contact: fight outcomes characterization concerning their methods, occurrence times and technical-tactical developments. *International Journal of Environmental Research and Public Health*. 17(19), 70-94. <https://doi.org/10.3390/ijerph17197094>

Beyond these papers, some presentations and papers conducted as a preliminary approach to ultimate full contact performance:

- **Loio, F.**, Neiva, H., Nunes, C., Branquinho, L., & Ferraz, R. (2020). Ultimate Full Contact offensive efficiency analyzed through styles and

combat distances: a confluence of cognitive and ecological approaches. - Costa Blanca Sport Science Events - Advanced research in sports science: Trends and Topics – Alicante – Spain.

- **Loio, F.**, Neiva, H., Nunes, C., Branquinho, L., & Ferraz, R. (2020). Anticipated, simultaneous and posterior counter-attack efficiency In Ultimate Full Contact. - International Conference on Technology in Physical Activity and Sport – TAPAS.
- **Loio, F.**, Neiva, H., Marinho, D.A., Marques, M.C., Branquinho, L., Ferraz, R. (2021). Desportos de combate híbridos em “Full Contact”: teorização da performance dos lutadores e recomendações práticas para a intervenção dos treinadores. *Centro de Pesquisa e Desenvolvimento Desportivo do Comité Olímpico de Portugal*. Available online: [http://formacao.comiteolimpicoportugal.pt/Publicacoes/COP\\_PFO\\_TD/fil\\_eo19.pdf](http://formacao.comiteolimpicoportugal.pt/Publicacoes/COP_PFO_TD/fil_eo19.pdf)
- **Loio, F.**, Neiva, H., Marques, M.C., Marinho, D.A., Branquinho, L., Ferraz, R. Utilizing contextualized skills and coach Intervention to optimize Ultimate Full Contact fighters’ performance. *Ido Movement for Culture. Journal of Martial Arts Anthropology*. (Accepted for publication in October 2022, vol. 22, issue. 4).

# Abstract

The technical-tactical factor has proved a determinant dynamic to win in combat sports. The representative knowledge on this subject is presented as an asset to optimize training and fighters' performance. However, studies in hybrid full contact combat sports are limited. Thus, the main purpose of this investigation was to analyse the technical-tactical performance of global top-ranked fighters in the World Ultimate Full Contact Championships held annually in Portugal between 2008 and 2017. For integral understanding of the phenomenon, the following holistic approach was used: (i) reviewing the available literature; ii) reporting the theoretical basis of technical-tactical behavior and its application in ultimate full contact training; (iii) investigating ultimate full contact offensive efficiency analyzed through styles and combat distances; (iv) investigating anticipated, simultaneous and posterior counterattack efficiency in ultimate full contact; (v) investigating ultimate full contact defensive efficiency and ground fighting control, interrelating the different technical-tactical skills; and (vi) characterizing ultimate full contact fight outcomes in terms of methods, occurrence times and technical-tactical developments. The main conclusion was: (i) the technical-tactical performance requires ultimate full contact fighters to be efficient in all gestural and behavioural dynamics, supported by cognitive and dynamic-ecological approaches; (ii) it is not enough to be efficient only in ground fighting or only in stand-up fighting, or to be efficient offensively without being efficient defensively or counter-offensively, (iii) and to act spontaneously to contextual opportunities without rationally opting for biomechanically correct action, properly adjusted to opportunities and at the right time; (iv) there are multiple interrelated variables of performance which must be developed in an all-inclusive and balanced way for the best performance in combat—i.e., styles and skills versatility and automation, contextual adaptability and seizing opportunity (distances and opponent stimulus), unpredictability, anticipation, combinations, fighting control, decision-making and perception, associated with volitional capacity and adjusted physiological intensities.

## Keywords

dynamics;technical;tactical;styles;skills;distances;offensive;counteroffensive;defensive; control;efficiency;ground;stand-up;fighting;submission;striking;outcomes.



# Resumo

O fator técnico-tático tem-se revelado como determinante para a vitória nos desportos de combate. O seu conhecimento representativo é apresentado como um trunfo para otimizar o treino e o desempenho dos lutadores. No entanto, os estudos em desportos de combate híbridos em full contact são escassos. O principal objetivo desta investigação foi analisar a performance técnico-tática dos lutadores de topo mundial nos Campeonatos Mundiais de Ultimate Full Contact WUFC que se realizaram anualmente em Portugal entre 2008 e 2017. Para a compreensão integral do fenómeno seguiu-se uma abordagem holística sobre múltiplas variáveis do desempenho: (i) revisão da literatura existente; (ii) relatório sobre as bases teóricas do comportamento técnico-tático e sua aplicação no treino de Ultimate Full Contact; (iii) investigação da eficiência ofensiva analisada através dos estilos e distâncias de combate; (iv) investigação da eficiência do contra-ataque: antecipado, simultâneo e posterior; (v) investigação da eficiência defensiva e de controle na luta no solo, inter-relacionando as diferentes habilidades técnico-táticas; (vi) investigação dos resultados da luta quanto ao método, tempo de ocorrência e desenvolvimentos técnico-táticos. A principal conclusão revela que o desempenho técnico-tático exige que os lutadores sejam eficientes em todas as dinâmicas gestuais e comportamentais, apoiado numa abordagem cognitiva e dinâmico-ecológica. Ou seja, não bastará ser eficiente apenas na luta no chão ou apenas na luta em pé; ou ser eficiente na ação ofensiva sem ser eficiente na defensiva ou na contraofensiva; bem como atuar espontaneamente nas oportunidades contextuais sem racionalmente optar pela ação bio mecanicamente correta, ajustada às oportunidades e no momento certo. São múltiplas variáveis de desempenho, inter-relacionadas e que devem ser desenvolvidas de forma abrangente e equilibrada para um melhor desempenho (versatilidade e automatização de estilos e de habilidades, adaptabilidade contextual e aproveitamento de oportunidades - distâncias e estímulos do oponente, imprevisibilidade, antecipação, combinações, controle de luta, tomada de decisão e percepção, associado à capacidade volitiva e intensidades fisiológicas ajustadas).

## Palavras-chave

dinâmicas;combate;técnica;tática;estilos;habilidades;distâncias;controle;eficiência; ataque;contra-ataque;defesa;estratégia;antecipação;nocaute;submissão.



## **Resumen**

El factor técnico-táctico ha demostrado ser un factor determinante para la victoria en los deportes de combate. Su conocimiento representativo se presenta como un activo para optimizar el entrenamiento y desempeño de los luchadores. Sin embargo, los estudios en deportes de combate híbridos en pleno contacto son escasos. El principal objetivo de esta investigación fue analizar el desempeño técnico-táctico de los mejores luchadores del mundo en los Campeonatos Mundiales Ultimate Full Contact WUFC que se llevaron a cabo anualmente en Portugal entre 2008 y 2017. Para comprender completamente el fenómeno, se siguió un enfoque holístico en múltiples variables de desempeño: (i) revisión de la literatura existente; (ii) informar sobre las bases teóricas del comportamiento técnico-táctico y su aplicación en el entrenamiento de Ultimate Full Contact; (iii) investigación de la eficiencia ofensiva analizada a través de estilos y distancias de combate; (iv) investigación de la eficacia del contraataque: anticipado, simultáneo y posterior; (v) investigación de la eficiencia defensiva y de control en los combates sobre el terreno, interrelacionando las diferentes habilidades técnico-tácticas; (vi) investigación de los resultados de la pugna en cuanto al método, tiempo de ocurrencia y desarrollos técnico-tácticos. La principal conclusión revela que el desempeño técnico-táctico requiere que los luchadores sean eficientes en todas las dinámicas gestuales y conductuales, apoyados en un enfoque cognitivo y dinámico-ecológico. En otras palabras, no será suficiente ser eficiente solo en la lucha en el suelo o solo en la lucha de pie; o ser eficiente en la acción ofensiva sin ser efectivo en la defensiva o contraofensiva; así como actuar de forma espontánea en las oportunidades contextuales sin optar racionalmente por una acción biomecánicamente correcta, ajustada a las oportunidades y en el momento oportuno. Existen múltiples variables de desempeño, interrelacionadas y que deben desarrollarse de manera integral y equilibrada para un mejor desempeño (versatilidad y automatización de estilos y habilidades, adaptabilidad contextual y aprovechamiento de oportunidades - distancias y estímulos del oponente, imprevisibilidad, anticipación, combinaciones, control de la lucha, toma de decisiones y percepción, asociadas a la capacidad volitiva e intensidades fisiológicas ajustadas).

## **Palabras-clave**

dinámica;combate;técnico;táctica;estilos;habilidades;distancias;controlar;eficiencia; ataque;contraataque;defensa;estrategia;anticipación;knockear;sumisión.



# Table of Contents

|  |            |
|--|------------|
| Acknowledgments  | vii        |
| List of Publications   | ix         |
| Abstract   | xi         |
| Resumo   | xiii       |
| Resumen  | xv         |
| Index of Tables  | xix        |
| List of Abbreviations  | xxi        |
| <b>Chapter 1</b>   | <b>1</b>   |
| General Introduction   | 1          |
| <b>Chapter 2</b>   | <b>7</b>   |
| Literature Review  | 7          |
| Review Study   | 27         |
| Study 1 – Theoretical Basis of Technical-tactical Behavior and its<br>Application in Ultimate Full Contact Training  | 27         |
| <b>Chapter 3</b>   | <b>35</b>  |
| Observational Studies  | 35         |
| Study 2 – Ultimate Full Contact offensive efficiency analyzed<br>through styles and combat distances: a confluence of cognitive<br>and ecological approaches | 35         |
| Study 3 – Anticipated, Simultaneous and Posterior Counter-<br>Attack Efficiency in Ultimate Full Contact   | 51         |
| Study 4 – Ultimate Full Contact: defensive efficiency and ground fighting<br>control, interrelating the different technical-tactical skills                  | 67         |
| Study 5 – Ultimate Full Contact: fight outcomes characterization<br>concerning their methods, occurrence times and technical-tactical<br>developments        | 79         |
| <b>Chapter 4</b>   | <b>91</b>  |
| General Discussion   | 91         |
| Practical applications   | 98         |
| <b>Chapter 5</b>   | <b>101</b> |
| Overall Conclusions  | 101        |
| <b>Chapter 6</b>   | <b>105</b> |
| Suggestions for Future Investigation   | 105        |
| <b>Chapter 7</b>   | <b>107</b> |
| References   | 107        |



# Index of Tables

## **Chapter 2 Literature Review**

|  |    |
|--|----|
| Table 1. Main sports techniques WUFC                         | 13 |
| Table 2. Complexity levels of the exercises                  | 15 |
| Table 3. Tactical training methodology - Cognitive approach  | 16 |
| Table 4. Tactical training methodology - Ecological approach | 17 |

## **Chapter 3 Study 2.**

|  |    |
|--|----|
| Table 1. Descriptive data of fight distances efficiency, styles efficiency and its technical tactical actions efficiency | 42 |
| Table 2. Mann–Whitney test effectuated between winners and losers, in the different variables of offensive efficiency    | 43 |
| Table 3. Spearman’s correlation coefficients obtained between distance and style efficiencies                            | 44 |

## **Chapter 3 Study 3.**

|   |    |
|---|----|
| Table 1. Descriptive data of technical tactical actions of counter-attacks made, and effective, by winners and losers       | 57 |
| Table 2. Spearman correlation coefficients obtained between counter-attacks made and effective                              | 58 |
| Table 3. Descriptive data of technical tactical actions of counter-attacks efficiency                                       | 59 |
| Table 4. Mann–Whitney test effectuated between winners and losers, in the different variables of counter-attacks efficiency | 60 |

## **Chapter 3 Study 4.**

|   |    |
|---|----|
| Table 1. Descriptive data of defensive technical tactical actions and general defensive efficiency  | 71 |
| Table 2. Mann–Whitney U test effectuated between winners and losers, in the different variables of defensive efficiency                     | 72 |
| Table 3. Descriptive data of successful ground fighting control skills  | 73 |
| Table 4. Mann–Whitney U test effectuated between winners and losers in the different variables of successful ground fighting control skills | 74 |

## **Chapter 3 Study 5.**

|  |    |
|--|----|
| Table 1. Fight outcome characterization regarding the methods and occurrence | 85 |
|--|----|

times

Table 2. Fight outcomes' characterization in terms of the inherent technical– tactical actions. 85

Table 3. Technical–tactical characterization in terms of their development 86

# List of Abbreviations

|         |  |
|---------|--|
| ADCC    | Abu Dhabi Combat Club Submission - World Championship        |
| Av      | Average  |
| CD      | Close Distance   |
| DPCR    | Dan Pankration Committee of Russia                           |
| DS      | Doctor Stoppage  |
| EVT     | European Vale Tudo   |
| FPFC    | Federação Portuguesa de Full Contact                         |
| FRPD    | Federation "Pankration" of Republic Dagestan                 |
| GBA     | Golden Belt Martial Arts Association                         |
| GS      | Ground Strikers  |
| IFMA-FF | International Federation of Martial Arts - Free Fight        |
| ITF     | International Taekwondo Federation                           |
| IQR     | Interquartile Range  |
| KO      | Knockout   |
| L       | Losers   |
| LD      | Long Distance  |
| M-1     | Mix Fight  |
| Me      | Median   |
| Min-Max | Minimum-Maximum  |
| MMA     | Mixed Martial Arts   |
| PLP     | Professional League of Pankration                            |
| RSCP    | Russian Sports Center Pankration                             |
| SC      | Superior Challenge   |
| SD      | Short Distance   |
| SD      | Standard Deviation   |
| SG      | Submission Grapplers   |
| SUS     | Stand-Up Strikers  |
| TKO     | Technical Knockout   |
| UIPDA   | L'Union Internationale de Pancrace et Disciplines Assimilées |
| USA     | United States of America                                     |
| W       | Winners  |
| WBC     | World Boxing Council   |
| WT      | World Taekwondo  |
| WLP     | World League Pankration                                      |
| WUFC    | World Ultimate Full Contact                                  |



# Chapter 1. General Introduction

Ultimate full contact is a hybrid combat sport developed in Portugal, contested annually since 1988 through the World Ultimate Full Contact Championships (WUFC), organized by the World Ultimate Full Contact Association (Pinto, 2015). This is a high-level competition with high international representation, where around 120 global top-ranked fighters from different martial arts/combat sports regularly participate (Federação Portuguesa de Full Contact, 2018a; Sherdog, 2020; Veiga, 2009; WUFC, 2018).

Ultimate full contact is characterized as a combat sport of extreme technical-tactical complexity (i.e., global fighting) and of intermittent intensity in physiological aspects, articulating a large variety of individual and combined actions. In fact, this type of combat allows both ground fighting and stand-up fighting with striking and submission grappling skills under conditions of high tenacity, variability and unpredictability (Federação Portuguesa de Full Contact, 2018b; Pinto, 2015). It is a complex dynamic which requires fighters to carry out multiple and effective actions in short periods of time, making it essential to perceive and anticipate quickly, and to decide and act appropriately at the right time for the purpose of the combat/game (Castelo et al., 1996; Pinto, 2015). This complexity is increased by the emotional pressure, which is higher in hybrid full contact sports, since fights develop with constant and power strikes and high amplitude takedowns, where the knockout can happen at any moment (Hutchison et al., 2014; Pinto, 2015). This high emotional pressure requires fighters to have high perceptual-cognitive and volitional capacities (Pinto, Petri et al., 2018; 2015; Shih & Lin, 2016). Therefore, in addition to psychological demands, this is a modality that requires high cognitive and physiological processes as fundamental demands of competitive performance. These are factors that have contributed to the need for increasingly sophisticated combat strategies, exponentially raising the technical-tactical level in ultimate full contact. In fact, according to a study carried out by Pinto (2015), the skills related to technical-tactical factors and psychological capacities are in general the most valued by all coaches and athletes of various combat sports/martial arts styles—i.e., taekwondo, ultimate full contact, pankration, free-fight, mixed martial arts (MMA), full contact, Muay Thai, kickboxing boxing, judo, wrestling, jiu jitsu and karate. This is in line with previous studies in combat sports, where showed that a high level of technical-tactical skills and physical fitness were required in combat (Franchini et al., 2011; Franchini & Takito, 2014; Miarka et al., 2020). In fact, the best fighters

were characterized by technical-tactical success during the fights (Atan & İmamoğlu, 2005; Miarka, 2016; Miarka, Fukuda, et al., 2016).

Furthermore, there is a consensus in the literature regarding the importance of technical and tactical aspects in several combat sports, since they are determinant factors in competitive performance: winners have shown higher efficiency in all offensive, counteroffensive and defensive dynamics (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2017; Koropanovski et al., 2008; Koropanovski & Jovanović, 2007; Romashov, 2019; Slimani et al., 2017; Wąsik et al., 2014). In addition, this set of qualities and capabilities has been described as fundamental to technical-tactical performance, and as characteristic of elite fighters and winners, including: anticipated actions; timing motion; unpredictably or spontaneous actions; perception/interpretation; memory working; decision-making; technical automation; accurate and quick perception; action combinations; technical actions frequency; situational spatiotemporal control and synchronization; skills versatility; seizing opportunity; fast and accurate attack; good footwork (i.e., displacements); proper balance; distance control; strategic analysis and fluid movement around the opponent (Adam et al., 2015; Castelo et al., 1996; Hao, 2019; Jaspe et al., 2011; Keller & Tyshler, 1972; Krabben et al., 2019; Lee, 1975; Mahlo, 1997; Malkov & Ramashov, 2019; Menescardi et al., 2019; Milazzo et al., 2016; Shih & Lin, 2016; Slimani et al., 2017; Urquidez, 1981; Vidranski et al., 2015; Wallace, 1982). Moreover, winners display more varied behaviours and have a greater technical-tactical repertoire (Menescardi et al., 2020).

The abovementioned characteristics, which are observed in the context of competition, allow coaches to adjust the training process according to the level or experience of the fighter, age, gender, weight category and combat style (Slimani et al., 2017). In addition, visualizing specific combat situations can be important in the development of technical-tactical competition strategies, improving attack effectiveness and specific defensive actions (Menescardi et al., 2019). This is because, according to what was previously described, the technical-tactical performance in competition is linked to the contextualized training practice (Barna, 2013; López-González, 2014; López-González & Miarka, 2013; Miarka et al., 2010). Therefore, it seems pertinent to observe and analyze athletes' performance in order to develop knowledge (e.g. quantification, representativity, technical-tactical effectiveness, trends, regularities, errors, technical characteristics) and to arrange more efficient training processes (Atan & İmamoğlu, 2005; Badilin, 2014; Boguszewski, 2014a; De la Fuente & Castejón, 2016; Del Vecchio et al., 2011; Kalina, 2000; Miarka, 2016; Miarka et al., 2016; Santos et al., 2011).

In this reasoning, specific technical-tactical characteristics in different combat sports; comparing the performance in terms of skills; fight outcomes (i.e., winners and losers); and fighters' experience, gender and ages have been investigated—for example, in judo (Boguszewski, 2016; Ito et al., 2013; Miarka et al., 2016), in wrestling (Barna, 2013; Gierczuk & Bujak, 2013; López-González, 2014), in boxing (Davis et al., 2013; Kruszewski et al., 2016; Romashov, 2019; Slimani et al., 2017), in karate (Petri et al., 2018; Vidranski et al., 2015), in taekwondo (Avakian et al., 2017; Śledziewski et al., 2015; Wąsik et al., 2014), in kickboxing (Ouergui et al., 2013), in sanda (Hao, 2019), in Muay Thai (Cappai et al., 2012) and in mixed martial arts (Adam et al., 2015; Amtmann, 2004; Del Vecchio et al., 2011; Faro et al., 2020; Kirk et al., 2015; Miarka et al., 2017).

More recent investigations looking at Olympic judo fighters have reported technical-tactical dynamics as a very important factor, favoring the tactical dimension, while the technique should be developed first at an earlier age. However, some authors (Rodríguez et al., 2018) consider that training should be integrated (i.e., physical-technical-tactical), respecting the principle of training indivisibility—that is, organizing and carrying out the training process through methods representative of competition (e.g. sparring) according to a dynamic-ecological approach. This is in line with the interactive approach, in which both fighters, through opportunities perception, act spontaneously (i.e., attack and defend) in a continuous co-adaptation behavior seeking to take advantage of the variability of the context (Krabben et al., 2019). Nevertheless, cognitive performance has been determinant in elite fighters, who show improvements, in reaction time and accuracy immediately after exhausting exercise (Faro et al., 2020). In addition, perceptual cognitive skills in combat sports are highly necessary—i.e., complex cognitive skills and basic cognitive functions that offer the ability to discern relevant stimuli to anticipate attack and decide how to counterattack (Russo & Ottoboni, 2019). In fact, previous study has shown that the ability to anticipate and quickly perceive kinematic patterns in the techniques that the opponent intends to perform is a differentiating variable between fighters of different levels (Mori et al., 2002). Thus, the cognitive dimension has demonstrated a consistent role in improving performance (Faro et al., 2020; Tod et al., 2015). This means that demands such as experience, memory, high concentration and attention are required to correct decision-making and to act offensively or defensively at the precise moment and anticipate opponents' actions (Afonso et al., 2012; Mahlo, 1997). Consequently, it seems necessary to consider the development of technical-tactical behaviours simultaneously from both the cognitive and the dynamic ecological perspectives. This seems to be the best way to improve fighters' performance, combining the ability to perform specific and correct

actions at the right time in each fighting moment with quick adaptation to contextual variability.

However, the aforementioned studies were mostly carried out in modalities that, despite performing some techniques like those of ultimate full contact, are developed in a different context. Trying to make a submission technique in a context where striking is not allowed, however, is very different from when it is. In fact, most of the studies presented result from analyses carried out in modalities whose competitions allow a restricted number of technical executions and tactical resolutions when compared to ultimate full contact. Also, the rules are different, which leads to differences in dynamics. Indeed, technical-tactical analysis through competition allows us to determine references for training programs contextualized and adapted to the requirements and regulations of a specific combat sport (Adam et al., 2016; Avakian, 2017; Miarka, 2016). Consequently, preparation for different competition rules requires the assessment of specific objectives (Adam et al., 2011; Ito et al., 2013; Ito et al., 2015). Thus, fighters show different profiles of perceptual-motor performance in distinct combat sports (Chen et al., 2017). Even in the same modality, regulatory changes imply distinct technical-tactical dynamics (Menescardi et al., 2020).

Therefore, some questions arise. Knowledge of previous investigations is not representative of the ultimate full contact modality, since it generally results from modalities with different characteristics, such as in Olympic taekwondo, where essentially leg techniques are used; in boxing, where only punches are used; in kickboxing/karate/taekwondo, where only punch and kick techniques are used; or in wrestling/judo/jujitsu, where only submission grappling skills are allowed. Only a few studies have been carried out on the technical-tactical approach in similar modalities (i.e., hybrid full contact combat sports).

In addition, previous studies have analyzed the technical-tactical behavior under cognitive or ecological approaches, highlighting one or another perspective of thought. Moreover, offensive efficiency concerning the different fighting styles in relation to distances under cognitive and dynamic-ecological approaches is not scientifically known; there are no studies associated with counter-offensive efficiency concerning temporal responses (anticipated, simultaneous and posterior), or studies on ultimate full contact that report fights' outcomes in terms of methods in respect of occurrence times, inherent skills and their development form, as well as defensive efficiency and ground fighting control. Those are all useful variables from different technical gestures and tactical behaviours that can better explain fighters' performance and provide a holistic understanding of the technical-tactical dynamic. Correct knowledge of those multiple performance variables seems essential to improve the ultimate full contact

training process, and certainly to extrapolate knowledge to similar modalities, such as pankration, free-fighting, shooto or mixed martial arts.

Considering the above, the main purpose of this thesis was to fully analyze the technical-tactical performance demonstrated by top-ranking fighters at the WUFC Championships, identifying and characterizing in a competitive context specific technical-tactical dynamic and their efficiency that are decisive in performance, through all fighting dynamics.

It was hypothesized that the technical-tactical performance in ultimate full contact requires fighters to be efficient in all fighting dynamics (offensive, counter-offensive, defensive and ground fighting control).

The present thesis is organized and developed in the following sequence:

- Chapter 2 presents the literature review and a review study concerning the theoretical basis of technical-tactical behavior and its application in ultimate full contact training (Study 1).
- Chapter 3 shows the observational studies developed to accomplish the main aim of this thesis:
  - Study 2 explores ultimate full contact offensive efficiency, analyzed through styles and combat distances: a confluence of cognitive and ecological approaches.
  - Study 3 focuses on anticipated, simultaneous and posterior counterattack efficiency in ultimate full contact.
  - Study 4 examines ultimate full contact: defensive efficiency and ground fighting control, interrelating the different technical-tactical skills; while
  - Study 5 is dedicating to ultimate full contact fight outcome characterization concerning methods, occurrence times and technical-tactical developments.

After the studies presentation, a general discussion of the results obtained is provided (Chapter 4), followed by the main conclusions of the thesis (Chapter 5), and some suggestions for future research. (Chapter 6).



## **Chapter 2. Literature Review**

### **Theoretical Context of Combat Arts**

#### **Full Contact: The Predecessor and Improver of Other Combat Arts**

Combat sports were developed from martial arts or are the sportive part of some martial arts, such as taekwondo, and both versions—martial and sports—comprise the four Olympic combat sports (i.e., boxing, judo, taekwondo and wrestling) (Pinto, 2015). Martial arts are associated with the traditional art of war fighting; in addition, they are nowadays associated with self-defense, while combat sports are associated with competitions held according to rules standardized by sports organizations (Filho & Maccariello, 2009; Pinto, 2015). Fighting has acquired a practical, religious, mystical, cultural and sporting character over the years under various forms according to the ideologies and values of the social groups that practice it (Pinto, 2015).

Based on the ancient pankration, ultimate full contact was established in 1988 by the WUFC Association (Federação Portuguesa de Full Contact, 2018a; Pinto, 2015), structured from taekwondo, American full contact, boxing, Muay Thai, kickboxing and submission grappling styles (i.e., close fighting or hand-to-hand combat). The main concept was full contact fighting considering the principles of martial arts (Federação Portuguesa de Full Contact, 2018a; Pinto, 2015).

According to the FPFC (2018a), Pinto (2015) and Urquidez (1981), full contact emerged as a sport in the United States of America in the early 1970s, seen as a futuristic modality. It allowed all fighters to explore new methods and to combine them with already established techniques: it was expected that this would translate into an improvement of combat practice (Pinto, 2015; Urquidez, 1981). In fact, full contact does not claim a single martial arts style but gives credit to all fighting arts for its application (Federação Portuguesa de Full Contact, 2018a; Pinto, 2015; Urquidez, 1981). This fighting method is characterized by a combination of martial arts techniques and boxing techniques (Pinto, 2015; Urquidez, 1981; Wallace, 1982). In fact, through full contact, new techniques for training and combat competitions have emerged via the modification of many traditional methods (Pinto, 2015; Urquidez, 1981).

## **Ultimate Full Contact: An Affirmation Process in Portugal and Around the World**

To support and regulate ultimate full contact, the WUFC Association was established in 1988 in Portugal, forming a series of partnerships with international organizations such as L'Union Internationale de Pancrace et Disciplines Assimilées (UIPDA), the Professional League of Pankration (PLP), the International Federation of Martial Arts – Free Fight (IFMA-FF), the Federation Pankration, Republic Dagestan (FPRD), the Russian Sports Centre Pankration (RSCP) and Golden Belt Martial Arts Association (GBA) (Federação Portuguesa de Full Contact, 2018a; Dan Pankration Committee of Russia [DPCR], 2020; World League Pankration [WLP], 2020). This union allowed Portugal to be represented in the first international events of Pankration, Free-Fight and Vale Tudo/MMA, organized in different countries such as Russia, Sweden, Ukraine, Iran, Brazil, Bulgaria, England, Denmark, Czech Republic, Spain, Switzerland, Netherlands, Germany, Italy, Belgium, France and Scotland (Federação Portuguesa de Full Contact, 2018a, 2018b). Since then, Portugal has been represented systematically in more than a thousand events worldwide. The first and largest Portuguese team competed in eight elements in a professional pankration championship, Cup of Challenge – Portugal Vs Russia (an event sanctioned by the PLP and WUFC), held in Barnaul, Russia, in 2004 (Federação Portuguesa de Full Contact, 2018a, 2018b; Sherdog, 2017), and in many other great events such as European Vale Tudo (EVT), M-1 Mix Fight, Superior Challenge (SC), Battle of Champions and Free-Fight Peresvit. In Portugal, the activity gained prominence and consolidation with the annual organization since 1988 of the WUFC Championships, a relevant international event where world class fighters regularly participate (Federação Portuguesa de Full Contact, 2018a, 2018b; Sherdog, 2020; Veiga, 2009; WUFC, 2018).

## **Physical Perspective of Ultimate Full Contact**

Ultimate full contact is a combat sport, like pankration, free-fight or MMA, of special complexity, where a great number of technical-tactical actions are allowed, with intermittent physiological intensity (Amtmann, 2004; FPFC, 2015; Pinto, 2015).

In fact, ultimate full contact brings together numerous striking and submission grappling skills, allowing stand-up fighting and/or ground fighting (Pinto, 2015), as in MMA (Federação Portuguesa de Full Contact, 2018c; James et al., 2016; Kirk et al., 2015; Miarka et al., 2017). The high variability of technical-tactical actions implies varied efforts (Cipriano, 1993; Del Vecchio et al., 2015; Fargas, 1990; Heller et al., 1998; Kazemi et al., 2010; López-González, 2011; Marcovic et al., 2008; Pieter, 1991). In fact, the striking and submission grappling skills are associated with powerful blows and

large amplitude takedowns/throws, creating hard impacts among skills of lower intensity such as defense, displacement, stance or moments of strategic analysis by the fighters (Federação Portuguesa de Full Contact, 2018c; Del Vecchio et al., 2015; Kazemi et al., 2009; Kazemi et al., 2010; Menescardi et al., 2012). This in line with Pinto (2015), who expressed that the physical contact in ultimate full contact is constant and full, with the opposition of maximum force (i.e., isometric contraction used mainly in fighting on the ground) and physical impact (i.e., collisions from takedowns and strikes and counter strikes) of significant power (i.e., explosive and reactive force) throughout the fight. In this respect, takedown skills have shown significantly greater intensity than strikes, either in isolated form or in open sparring (Kirk et al., 2015). In addition, Chernozub and colleagues (2018) expressed that grappling on the ground is more associated with low intensity in terms of glycolytic energy resources, while striking skills are more associated with high intensity alactic or lactate energy resources. Nevertheless, comparing the intensities of the same skills performed in isolation and in a sparring context, varied intensities were found for the same skills; this demonstrates that the skills' intensity varies according to the contextual complexity (Kirk et al., 2015). Thus, the physiological factor is conditioning for technical-tactical efficiency (Kirk et al., 2015). This means that both a high level of technical-tactical skills (i.e., determinant factors), and high physical fitness (i.e., conditioning factor) are required in combat (Amtmann, 2004; Chernozub et al., 2018; Franchini et al., 2011; Franchini & Takito, 2014; Miarka et al., 2020; Pinto, 2015). In this reasoning, the training process should involve various technical-tactical exercises, carefully regulated with physiological load to obtain adjustable adaptations, as physiological conditioning can influence the technical-tactical performance (Amtmann, 2004; Chernozub et al., 2018).

For better knowledge about the physiological demands of ultimate full contact, it is necessary to know its structural essence. It is a combat art based on pankration and was influenced by martial arts/combat sports with striking skills (i.e., taekwondo, boxing, American full contact, kickboxing, Muay Thai) and submission grappling (Federação Portuguesa de Full Contact, 2018a; Pinto, 2015). However, all mentioned modalities have restricted competition rules compared to ultimate full contact or pankration. For example, in the abovementioned striking combat sports, World Taekwondo allows kicks to the head and body, and punches to the body (Avakian, 2017; Kim, 2006; World Taekwondo Federation [WTF], 2020), while the International Taekwondo Federation allows kicks and punches to the head and body (Wąsik et al., 2014). In boxing, only punches to the head and body are allowed (El Ashker, 2017; Davis et al., 2013; Kruszewski et al., 2016; World Boxing Council [WBC], 2020). In American full contact,

kicks and punches to the head and body are allowed, as well as back fist and sweeping (Federação Portuguesa de Full Contact, 2018c). Kickboxing permits kicks to the head, body and legs, and punches to the head and body (Ouergui et al., 2013; Slimani et al., 2016). Muay Thai allows kicks, knees to the head, body and legs, and punches to the head and body (Cappai et al., 2012; Del Vecchio et al., 2015). Submission grappling permits grips, takedowns, throws, chokes and joint locks (i.e., skills from sambo, wrestling and jujitsu, among other close fights) (Submission Fighting World Federation [ADCC], 2020). The striking combat sports mentioned are developed over three or more rounds of two or three minutes each, spaced by one-minute breaks (Avakian, 2017; FPMC, 2018c; Kim, 2006; WBC, 2020; WTF, 2020), while the submission grappling combat sports are developed in one round of six, eight, ten or twenty minutes (ADCC, 2020). Physically, the submission grappling styles depends more on strength and resistance, mainly using glycolytic energy sources (Chernozub et al., 2018; Rodríguez et al., 2018), while striking combat sports are characterized as sports of intermittent intensity with high and low efforts, mainly using alactic or lactate energy sources (Avakian, 2017; Chaabène et al., 2014; Chernozub et al., 2018; Fargas, 1990; Miarka, 2016; Tornello et al., 2013). Therefore, ultimate full contact brings together skills from all the mentioned fighting styles: it integrates all characteristics of both combat styles (i.e., striking and submission grappling), but with greater physiological demands due to its greater technical-tactical complexity.

## **Ultimate Full Contact Technical, Behavioral, Strategic, Perceptual and Volitional Determinants**

### **General Characterization**

Like any other hybrid full contact combat sport (e.g., pankration, free fight, shooto or MMA), ultimate full contact allows a multitude of technical-tactical actions in stand-up fighting and/or ground fighting with the occurrence of several strikes and grappling skills (i.e., punches, kicks, knee and elbow strikes, throws, takedowns, chokes and joint locks) (Federação Portuguesa de Full Contact, 2018c; James et al., 2016; Kirk et al., 2015; Miarka et al., 2017; Pinto, 2015). These are technical-tactical actions that regularly combine dexterity and precision with strength actions, developed in a context of high variability, unpredictability and tenacity (Pinto, 2015). Therefore, according to the sports classification (Castelo et al., 1996), ultimate full contact can be characterized as a sport with a complex structure similar to collective sports, where specific preparation is required, and which allows the simultaneous development of technical,

tactical and psychological components in order to enhance the performance of the fighters.

### **The Fight: Volitional Effort and Objectives**

The combat in ultimate full contact takes place in an environment of high emotional pressure due to its technical-tactical typology of intentional physical confrontation using the exchange of precise and explosive blows (Pinto, 2015). In fact, the fight shows a context in which the volitional capacity demarcated by competitiveness, courage and self-overcoming is of extreme importance, since the technical-tactical chains of offensive and counteroffensive actions are composed of explosive blows aiming not only to score, as in combat sports, in semi/light contact, but also knock out the opponent (Hutchison et al., 2014; Pinto, 2015). The objectives in combat are to avoid suffering blows, defend, dodge, immobilize, block or reverse the opponent's dominant positions and, in return, to make the greatest number of blows in certain anatomical regions of the opponent in order to weaken him/her and gain an advantage, the risk of being knocked out a constant reality, or to end the combat by using submission skills (i.e., chokes, joint locks) (Pinto, 2015). This is a context of high emotional pressure that requires of the fighters high perceptual-cognitive and volitional capacities (Petri et al., 2018; Pinto, 2015; Shih & Lin, 2016). However, all combat dynamics are developed in compliance with rules which allow the physical integrity of athletes to be preserved, and with the principles of martial arts and sport values that support a philosophy of self-disciplined and ethical behavior (Federação Portuguesa de Full Contact, 2018; Pinto, 2015; Sarmiento, 2005).

### **Strategic Technical-Tactical Characterization**

Ultimate full contact has a large technical-tactical repertoire and is extremely complex in terms of biomechanical structure and functionality in combat—maintaining frontal framing with the opponent and proper distance; proper stance and balance; moving through standing displacements/footwork and through movements on the ground; defending through evading dodging, slipping, parrying, blocking, immobilizations and inversions; striking with fists, elbows, knees, tibias and feet techniques; feinting or simulating; throwing and takedowns; submitting with chokes or joint locks (Federação Portuguesa de Full Contact, 2018c). These are systematic actions of complex execution, composed of a multiplicity of isolated/single or sequential segmental movements (i.e., combinations of skills) with constant changes of direction, some of them with great amplitude (i.e., leg techniques and high takedowns), structurally organized according to the objectives (Federação Portuguesa de Full Contact, 2018c; Pinto, 2015). To

achieve the objectives—that is, to successfully achieve their functionality—the fighting skills must comply with a series of structural constraints in terms of biomechanics in relation to movement kinetics and kinematics and motor control (Pinto, 2015). These constraints will allow even the weakest fighter to increase his performance in combat, taking advantage of his opponent's strengths for his own benefit, reducing effort through lever systems, and defending and attacking effectively through technical dexterity and bioinformation aptitude (Federação Portuguesa de Full Contact, 2018c; Pinto, 2015).

According to Rothig (1983) and Weineck (2001), the technique is a specific sequence of motor actions that aim to resolve the tasks required by certain sporting situations in a rational, efficient, safe and precise way to achieve predetermined goals. Thus, the technique presents itself as an ideal model and method of executing competitive action, representing the most efficient way of performing movements in biomechanical and physiological terms, it must be flexible and adaptable to individual characteristics so that the performer is accurate, efficient and safe in combat (Matveev, 1991).

Ultimate full contact includes different technical-tactical programs as martial art and sport. Since the present study addresses the sports aspect, it presents the main techniques used in competition according to the WUFC rules (Table 1).

**Table 1.** Main sports techniques

| <b>Fighting Stance / Control / Motion</b> | <b>Defence Actions</b> | <b>Attacks and Counterattacks</b>                      |                            |
|---|------------------------|--|----------------------------|
|   |                        | <b>Striking</b>  | <b>Submission</b>          |
| Clinch                                    | Blocking               | Jab  | Arm Bar                    |
| Rear Mount                                | Parry                  | Cross  | Anaconda Choke             |
| Body Triangle                             | Evading                | Hook   | Straight Ankle Lock        |
| Butterfly Guard                           | Dodging (Bobbing)      | Uppercut   | Keylock (Americana Kimura) |
| Closed Guard                              | Slipping               | Spinning Back Fist                                     | Arm Triangle Choke         |
| Footwork                                  | Sprawl                 | Fly Punch  | Chokehold                  |
| Grip                                      | Whizzer                | Overhand Punch   | Gogoplata                  |
| Striking Guard                            | Gazoni                 | Hammer Fist  | Guillotine Choke           |
| Grappling Guard                           | Spladle                | Ground and Pound                                       | Knee Bar                   |
| Half Guard                                | Escapes                | Elbow  | Leg Lock                   |
| Hip Escape                                | Flower Sweep           | Knee   | Omoplata                   |
| Grappling Hook                            | Guard Pass             | Flying Knee  | Rear Naked Choke           |
| Mission Control                           | Pendulum Sweep         | Low Kick   | Standing Guillotine Choque |
| Mount                                     | Scramble               | Roundhouse Kick  | Toe Hold                   |
| Open Guard                                | Side Mount Escape      | Front Kick   | Triangle Choke             |
| Orthodox Guard                            | Redirecting            | Side Kick  | Wristlock                  |
| Southpaw Guard                            | Displacements          | Hook Kick  |                            |
| Overhook                                  | Jamming                | Spinning Back Kick                                     |                            |
| Pivoting                                  | Clinching              | Spinning Wheel Kick / Back Swing Kick / Back Hook Kick |                            |
| Pull Guard                                | Leg Block              | Tornado Kick<br>360°/540°                              |                            |
| Rope-A-Dope                               | Mount Escape           | Axe Kick   |                            |
| Side Control                              | Reversal /Sweep        | Push Kick  |                            |
| Stance Posture Stand-Up                   |                        | Switch Kick  |                            |
| Step Step                                 |                        | Jump Kicks   |                            |
| Underhook                                 |                        | Jamming Heel Kick                                      |                            |
| X-Guard                                   |                        | Sweep  |                            |
| Tie Ups                                   |                        | Tackle (Throw Placagem)                                |                            |
| Duckunder                                 |                        | Double Leg Takedown                                    |                            |
| Arm Drag                                  |                        | Single Leg Takedown                                    |                            |
| Feint                                     |                        | Fireman's Carry  |                            |
| Faking                                    |                        | Back Arch (Suplex)                                     |                            |
|   |                        | Hip Throw  |                            |

According to the demands of ultimate full contact and individuals' characteristics, fighters develop their own styles (stand-up strikers, submission grapplers, ground strikers or versatile), associating specific skills with different combat distances (i.e.,

long range, short range and close range) (Federação Portuguesa de Full Contact, 2018c). Thus, they create an ideal standard of motor performance according to their morphological characteristics and capabilities. However, due to the complex structure of ultimate full contact, it is necessary to develop strategic and tactical plans.

Strategy can be defined as the decisions or special tactical plan for the game, along with other measures prior to the game (Gréhaigne & Guillon, 1992; Teodorescu, 1977), or as the objectives of the real combat plan (Clausewitz, 2005). Tactics are characterized by the choice of resources to carry out the strategic plan in order to solve competitive problems, considering the opponents' type of game and the rules (Duricek, 1985; Konzag, 1983). In this way, technical actions gain meaning when applied according to tactical options to solve emerging problems in different combat situations, using the maximum constraints, uncertainties and unpredictability (Gréhaigne & Guillon, 1992).

Some full contact strategies highlighted by Urquidez (1981) refer to when a fighter enters the ring: in the first round, he studies his opponent, testing his technical skills, determining his strengths and weaknesses; in the second round, he tests his opponent's body, its most vulnerable points; it is in the third round that the fighter really starts to target the opponent's weak points. The front arm (jab) is the basic blow to maintain distance and control the fight, serving as preparation for other blows: depending on the opponent's characteristics, the combat strategy is different (Urquidez, 1981)

However, Castelo (1996) comments that the technical gesture is practically inseparable from the sports tactic, expressing itself in the notion of technical-tactical action. In addition to the 'how' (motor realization), it is necessary to question the 'what', the 'when' and the 'why' (i.e., mental resolution) of actions and gestures. According to López-Ros and Avelar (2015), techniques and tactics are factors that must be developed simultaneously and in a contextualized way: in an isolated perspective, the technical requirement is reduced when teaching tactics, and vice versa. In fact, previous studies on similar combat sports have shown that high-level technical and tactical skills are required in combat, as demonstrated by the best fighters (Atan & İmamoğlu, 2005; Franchini et al., 2011; Franchini & Takito, 2014; Miarka, 2016; Miarka, Fukuda, et al., 2016; Miarka et al., 2020). Therefore, it is important to give special attention to the development of technical and tactical capabilities, since they maximize success in competition (Dal Bello et al., 2019).

### **Cognitive and Dynamic-Ecological Approach to Behavior in Ultimate Full Contact**

Technical-tactical behavior has been analyzed from the perspective of cognitive and ecological dynamics to understand the perceptions and decisions to act in competitive

contexts (Atan & İmamoğlu, 2005; Gréhaigne & Godbout; 1995; McPherson, 1994; Silva et al., 2013; Vilar et al., 2012; Williams et al., 2011). The analysis of technical-tactical behaviours in a cognitive perspective, which depends on actions previously experienced and memorized, refers to the tactical act as defined by Mahlo (1997), wherein the activity implies analysis and interpretation of the perceived situation and execution of the response with precision. This consists of a mental process with three phases: i) perception and analysis of the situation (i.e., identification of a problem); ii) decision (i.e., the most appropriate solution to the problem); and iii) action (i.e., motor execution) (Oliveira & Tavares, 1996). Mahlo's approach contributed to a significant advance in knowledge by revealing that decision-making embodied in an intellectual process to find practical solutions to different problems posed by diverse competitive situations should be quick and deliberate, trying to be as efficient as possible (Mahlo, 1997). In addition, cognitive performance has been shown to be relevant to elite fighters in terms of reaction time and accuracy, with improvement after exhaustive exercise (Faro et al., 2020). Perceptual cognitive skills in combat sports are needed to discern relevant opportunities and decide on a certain anticipated counterattack (Russo & Ottoboni, 2019), this performance being related to experience (De Quel & Bennett, 2019; Russo & Ottoboni, 2019). This is in line with the cognitive approach, where experience (i.e., repeated practice or number of fights) is highlighted as a central factor to improve a fighter's perception, accuracy of technique, and decision-making (Castelo et al., 1996; Mahlo, 1997).

The cognitive perspective is the basis for traditional thinking on fighters' behavior, where the teaching and training process is based on an analytical vision with pedagogical progression, presenting the exercise as a means of technical-tactical training. Molina and Castarlenas (2002) presented a progressive pedagogical method in combat sports which increases the degree of opposition and complexity through the teaching-learning process. Through this method, is also possible to develop coordination, the basis for technical development (Bolotin & Bakayev, 2018).

The complexity of the exercises, according to Rink (1985), can have the different situational levels showed in Table 2.

**Table 2.** Complexity levels of the exercises

|   |
|---|
| 1. Composed of simple skills without opposition   |
| 2. Combination of skills without opposition   |
| 3. Simplified opposition: passive, conditioned or reduced (cooperative)   |
| 4. Similar to the formal game (i.e., fight): level of opposition identical to competitive formality (i.e., active opposition) |

The tactical training methodology can be based on the traditional or cognitive perspective, according to the phases showed in Table 3 (Konzag, 1983).

**Table 3.** Tactical training methodology: cognitive approach

|  |  |
|--|--|
| 1. Learning and improving motor skills   | Learning the technical elements  |
|  | Consolidation of technical elements  |
| 2. Learning, stabilizing and improving technical-tactical actions                  |  |
| 3. Development, stabilization and improvement of the global cognitive capacity     | Competitive situations under facilitated conditions                                      |
|  | Competitive situations close to the actual competition                                   |
|  | Competitive situations more difficult than those posed by the reality of the competition |
| 4. Use and improvement of the global competitive capacity in official competitions |  |

In addition, from a dynamic-ecological perspective (Araújo et al., 2006; Fajen et al., 2008; Hristovski et al., 2006; Sánchez-García et al., 2015; Vilar et al., 2012), the assessment of decision-making is improved, capturing the interaction between the individual and the environment and the transitions in their course to achieve an objective, identifying the affordances (i.e., information specific to the events that occur in the environment) that enable the emergence of decisional behavior by seizing the opportunity to attack or counterattack (Hao, 2019). This is in line with the interactive approach, in which both fighters, through the perception of opportunities, act spontaneously (i.e., attack and defend) in continually co-adapting behavior looking to take advantage of the context variability (Krabben et al., 2019). According to Travassos (2014), training should be guided according to the representation of information that directs athletes' perception and action towards the objectives of the game (or fight), enhancing or inhibiting the possibilities of action. In this approach, training should be based on contextualized information (i.e., situational representativeness) such as distances between fighters, combat styles, preparation for attack/counterattack or reaction times. These are determining conditions for decisions during combat. The fighters' behaviours are influenced mainly by the situational and momentary issues in the fights. In this context, the intention is to train athletes to be capable of perceiving, interpreting and anticipating their opponent's intentions, developing a high decision-making capacity to neutralize the opponent's attacks and increase the efficiency and effectiveness of the attack (Pinto, 2015). According to this perspective, combat or sparring is understood as the means by which to achieve excellence in learning and consolidating technical-tactical actions, based on an integrated view of tactical training with phasing of combat levels.

The methodology of tactical training from an ecological perspective can be based on the assumptions showed in Table 4 (Ferreira, 2002).

**Table 4.** Tactical training methodology: ecological approach

|  |
|--|
| Simplification of the formal game (fight) in different types of game                 |
| Forms of exercise related to the type of game (fight)                                |
| Integration of exercise and types of play during instruction and play                |
| What kind of game (fight)?   |
| Preserve authenticity by representing a concept identical to the formal game (fight) |
| Contemplate the fundamental elements   |
| The presence of interaction with opponent  |
| Continuity of flow between the attack/defense phases                                 |
| Do not condition execution to closed response situations                             |

The ecological perspective (Barreto, 2001) manipulates variables such as space, time and rules, through forms played, reduced games and modified games. In ultimate full contact, this might mean: i) execution of attacks and defenses in pair (i.e., one-to-one), favoring technical development; ii) sparring using only legs skills or performing sparring in a reduced space, with the aim of privileging the development of certain technical-tactical behavior; or iii) sparring in which one of the fighters uses only strikes and the other only grappling, aiming to increase the tactical behaviours of each other according to opposite behaviours.

In this context, according to Milazzo et al. (2016), it is essential for coaches to devote more practice time to tactical learning approaches during the process of perceptual-motor training, in order to achieve significant improvements in athletes' decision-making and more efficient perception strategies. In this respect, a previous study showed that the skill to anticipate and quickly perceive the opponent's intent has been shown by high-level fighters (Mori et al., 2002).

The knowledge produced through studies in the field of collective sports on the dimension of technical-tactical performance can be extrapolated to the study of combat sports, with the aim of helping to reflect and understand technical-tactical behaviours. These studies present concepts, models, methodologies and technical-tactical training methods strongly supported by theories of behavior and knowledge, traditional or cognitive (Gréhaigne & Godbout, 1995; McPherson, 1994; Williams et al., 2011), situational or dynamic-ecological (Araujo et al., 2006; Silva et al., 2013; Vilar et al., 2012), and both declarative knowledge and convergent and divergent procedural knowledge (Greco, 2006; Lima et al., 2012).

The abovementioned studies mostly elaborate the training process according to the dynamic-ecological perspective as the ideal in the development of technical-tactical

behaviours. According to this approach, sparring (representative of competition) presents itself as the means by which to achieve excellence in the learning and consolidation of techniques and tactics. It is an integrated training process where technique and tactics are developed simultaneously through the sparring itself, using the phasing of fighting levels.

However, ultimate full contact, despite being a predominantly tactical modality like team sports, is individual and, in turn, a very technical modality, thus requiring primary attention to this factor. Its actions are complex in terms of biomechanical structure to achieve functionality safely, quickly, economically and successfully (Pinto, 2015). Therefore, the cognitive dimension has a consistent role in the improvement of performance (Faro et al., 2020; Tod et al., 2015). This means that experience, memory, high concentration and attention are required to make correct decisions and to act offensively or defensively at the right moment, anticipating the opponent's actions (Afonso et al., 2012; Mahlo, 1997).

In this reasoning, it does not seem appropriate to start learning combat sports through games/fights, but rather through a methodology based on the cognitive approach that is, by the traditional method in which the technical dimension of the sport is favored. In fact, the fight is characterized by constant exchange of different technical skills carried out singly or in combination, characterized by the need to achieve them with precision at the right time, where the use of ideal automated execution models becomes more efficient through a cognitive (rational) process (Castelo et al., 1996; Lee, 1975; Mahlo, 1997; Pinto, 2015)

Moreover, for a given attack, there are specific means of defense and counterattack (i.e., motor skills memorized and developed by experience), which the fighter will have to master and decide on the most appropriate action at the right time (Castelo et al., 1996; Lee, 1975; Mahlo, 1997; Pinto, 2015). It would be useless to do something at random that emerged instantly out of context of the opponent's actions: in fact, the performance of maladjusted or poorly executed techniques can expose the athlete, creating opportunities for the opponent. A technique only becomes efficient and effective when well executed (i.e., correct in an unstable environment).

It should be noted that when a technique is performed in ultimate full contact, it must be perfect, considering the objective of its execution (i.e., reaching the opponent) while simultaneously considering the defense; otherwise there is the risk of a counterattack by the opponent ending the fight by knockout. In other words, a technical error can be the end of the fight.

A study of Olympic fighters saw technical-tactical dynamics as a very significant aspect, favoring the tactical factor; however, the technique must be developed first, though the training must be integrated (Rodríguez et al., 2018).

Offensive efficiency depends on the proper and safe distance, and on agility, speed and synchronization capacity to correctly change distances and skills, the ability to perform several motions in different ways (Boguszewski, 2014a; Vidranski et al., 2015) being fundamental to each fighter trying to fight in his/her own style with the best fighting distances for him/her (Pinto, 2015). In addition, an offensive action requires the right execution at the right time (Keller & Tyshler, 1972; Malkov & Ramashov, 2019).

This is related to the fighter's experience, which is a relevant factor in developing self-improvement in terms of motor skills and cognitive perception to interpret and discern the opponent's intentions (Mahlo, 1997; Pinto, 2015).

However, the high complexity of ultimate full contact, where the variability (e.g. changes in rhythm) and transience (e.g. changes in complexity) limit the time to act properly, requires the athletes/fighters to demonstrate rapid perception, decision and anticipation skills (Castelo et al., 1996). These are important skills for the fighters' performance and their development, allowing adaptive motor skills and more effectiveness in terms of variation in the competitive situation (Milazzo et al., 2016; Pinto, 2015; Shih & Lin, 2016; Silva et al., 2011). In addition, the fighters will be able to act effectively in any style or at any combat distance using certain specific techniques at a precise moment (Fajen & Rilley, 2008; Hristovski et al., 2006). The skill decision derives from the individual-context interaction based on an ecological-dynamic perceptive (Araújo, 2005), where variability may have its cause in the individual (e.g. choosing to fight on the ground when they have rudimentary skills in stand-up fighting) or in the context (e.g., choosing to fight on the ground when the opponent is known to have strong skills in stand-up fighting).

Technical-tactical performance is related to the creative ability to adapt better to variability (Hristovski et al., 2011; Orth et al., 2017; Withagen & Van der Kamp, 2018), and to act on opportunities in the individual-context interaction (Araújo et al., 2006; Fajen et al., 2009; Kimmel & Rogler, 2019). In this interaction, experience (i.e., number of fights and time training) is a factor distinguishing the best fighters and is associated with a process of cognitive development (Abernethy & Russell, 1987; De Dreu et al., 2012; De Quel et al., 2019; Kostrubiec et al., 2012; Liu et al., 2006; McRobert et al., 2011; Moraru et al., 2016; North et al., 2009; Russo & Ottoboni, 2019; Thelen, 1995; Williams et al., 2011). In fact, high perceptual-cognitive skills should be present to anticipate and adjust correct actions (De Quel et al., 2019; Marteniuk, 1976; Russo & Ottoboni, 2019) through quick adaptation to spatiotemporal changes (Del Vecchio et

al., 2011). Therefore, the coordination and automation related to cognitive adaptation are the basis for technical improvement (Bolotin & Bakayev, 2018; Mahlo, 1997) and performing adjusted skills at the precise time (James et al., 2016).

### **Offensive Efficiency**

Ultimate full contact requires from fighters varied technical-tactical dynamics (i.e., offensive, counteroffensive and defensive) (Pinto, 2015). Where offensive activity and its efficiency are concerned, according to several combat sports investigations, these are demonstrated by the best fighters (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2017; Koropanovski et al., 2008; Koroponovski & Jovanović, 2007; Romashov, 2019; Slimani et al., 2017; Wąsik et al., 2014). Usually, this is the result of the ratio between effective attacks and attacks made: a higher ratio is related to higher offensive efficiency (Kalina, 2000, 2002).

For an attack to be efficient, it must be performed at the right time, quickly and unpredictably, with proper balance and distance control (Keller & Tyshler, 1972; Lee, 1975; Malkov & Ramashov, 2019; Urquidez, 1981; Wallace, 1982). In addition, attack combinations are considered an efficient strategy, since they always keep the opponent on the defensive (Slimani et al., 2017; Wallace, 1982), as well as fast and exact attack, correct displacements (i.e., footwork), strategic analysis, focus (i.e., attention, concentration) and fluid movement (Lee, 1975; Urquidez, 1981).

In terms of offensive skills, one of the most important conditions to be efficient is the ability to predict and adapt the right distance, as in the case of Wallace (1982), known as 'the fastest left leg in the world'. His technical-tactical system, using essentially only three leg techniques (i.e., roundhouse kick, side kick and hook kick), starts with distance, knee dislocation and position to provide the three techniques; the opponent cannot perceive which of the three techniques is being performed in time to react (i.e., block or counterattack). At issue is not to telegraph the movement, thus not giving signs of the attack in progress (i.e., unpredictability). The intention is to make the opponent constantly adopt a defensive position, at all times questioning which of the techniques he will be able to block or which will be effective.

However, situational spatiotemporal control and synchronization are decisive aspects to adjust correct actions with contextual variation (i.e., distances) (Krabben et al., 2019; Vidranski, et al., 2015). In this field, greater versatility increases the offensive success, since the fighters can adapt better with more technical resources to dominate their opponents (Adam et al., 2015; Urquidez, 1981), as is demonstrated by winners (Menescardi et al., 2020; Urquidez, 1981; Wallace, 1982). In these circumstances, fighters use different styles with specific skills characteristic of stand-up strikers

(fighters who prefer to fight standing, using strikes and counter-strikes), submission grapplers (fighters who favor apprehension/submission skills, preferring to take the fight to the ground, looking for the submission through locks and chokes); ground strikers (fighters who prefer to strike while fighting on the ground, known as 'ground and pound'); and versatile fighters (complete fighters who choose strategically to fight where the opponent is weaker) (Federação Portuguesa de Full Contact, 2018c). Thus, fighters move at distance with full contact strikes (i.e., punches, kicks and knees) and in stand-up clinches (i.e., close distance) with grips and takedowns, or on the ground with submission grappling skills (chokes and joint locks) and strikes (ground and pound) (James et al., 2016; Kirk et al., 2015; Kruyning & De Jong, 2014). These are varied and differentiated skills that should always be interrelated as vital conditions in the fight performance (Kirk et al., 2015). Their execution in combat is associated with offensive, counteroffensive and defensive dynamics, and they are determinant actions for the best performance, as winners have demonstrated (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2017; Koropanovski et al., 2008; Koropanovski & Jovanović, 2007; Romashov, 2019; Slimani et al., 2017; Wąsik et al., 2014).

In stand-up fighting, a greater number and effectiveness of offensive actions (i.e., punches, kicks, knee strikes) and a more technical performance increase the attack opportunity (Adam et al., 2015; Bocioaca, 2014).

In ground fighting, ground and pound is a decisive offensive action. This skill is related to a dominant position (e.g., mount), creating a clear advantage over the opponent (Adam et al., 2015). Previous studies have revealed higher efficiency of submission grappling skills, choke standing out as the most efficient skill. However, winners have shown high skills in both striking and grappling (Adam et al., 2015). Thus, it is necessary to develop balanced skills for greater performance in both stand-up and ground fighting (Segedi et al., 2014). In fact, submission grappling and accurate striking techniques have been shown as significant in winning fights (James et al., 2017).

### **Counteroffensive Efficiency**

Counterattack is a fight dynamic characteristic of winners, as shown in previous studies (Boguszewski, 2011; Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska 2006; Hao, 2019; Vidranski et al., 2015; Romashov, 2019). The efficiency of a counterattack is related to the ability to seize opportunities (Hao, 2019). This is a fighting skill that depends on the fighter's decision-making and the ability to take advantage of opportunities (Hao, 2019), using the opponent's mistakes to their own

advantage (Boguszewski & Boguszewska, 2006). Efficiency in counterattack is related to the ability to anticipate—that is, not waiting for the opponent to attack, but counterattacking when the opponent intends to attack (Hao, 2019; Malkov & Romashov 2018; Romashov, 2019; Urquidez, 1981; Wallace, 1982) or during the opponent's attack, evading and hitting them when they are unbalanced as a result of the failure of their attack (Hao, 2019; Romashov, 2019; Urquidez, 1981; Wallace, 1982). These different timely responses can interfere with efficiency fighting skills, since they are related to the cognitive process (Malkov & Romashov, 2018).

In ultimate full contact, the counterattack (e.g., anticipated, simultaneous or posterior) is an important and decisive behavioral dynamic in performance, where the probability of a knockout occurring is high due to the extreme difficulty in avoiding it and the increase in the impact force as a result of the combined forces in the movements of the attacker and the counter attacker (Federação Portuguesa de Full Contact, 2018c). Thus, the counterattack is a technical-tactical dynamic considered a safe and assertive strategy in a fight, waiting for the opponent to prepare an attack to counterattack them at the perfect moment (Hao, 2019; Wallace, 1982). This is a fighting strategy that puts great psychological pressure on opponents (Hao, 2019; Wallace, 1982), giving great control over the fight (Hao, 2019).

Ultimate full contact is a very complex combat sport with great technical-tactical variety influencing the tactical behavior in terms of quality, quick perception and situational interpretation (Castelo et al., 1996; Pinto, 2015). In fact, the variability (or pace of change) requires high cognitive-perceptual demands, since transience (or complexity of change) requires skills for efficient anticipation (Castelo et al., 1996).

The success of the counterattack depends on the cognitive ability of perception and speed of decision to execute the ideal technique for a given attack (Pinto, 2015; Russo & Ottoboni, 2019). In fact, such a procedure requires different abilities: the ability to anticipate the opponent's action in advance, speed of perception, interpretation and decision/determination on the execution of the perfect technique at the right time (Pinto, 2015). In turn, it is strategically essential for the attacker to carry out any offensive action in an unpredictable way, so that the opponent cannot predict the type of attack as quickly as necessary to defend or counterattack (Lee, 1975; Wallace, 1982). However, predictability can be an attacker's strategy, creating an opportunity by making his opponent perceive a certain intention of offensive action to anticipate and attack with a certain technique, and thus make it possible to counterattack him in a timely manner, with a deliberate technique (Lee, 1975). This is in line with a previous study, where fighters purposely revealed their moves for their opponents to attack them, then counterattacked with a planned skill (Ottoboni et al., 2015).

Similar to a study on sanda counterattack strategies by Hao (2019), in ultimate full contact technical programs there are several strategic counterattack plans, such as counterattack to jab (e.g. between two right-handed fighters - orthodox stance) performing inside lateral evading, applying a jab or right uppercut, or left roundhouse kick/low kick or cross, or performing outside evading, applying overhand punch; counterattack to a cross—performing outside evading, applying a cross or right roundhouse kick or left hook; counterattack to fist combinations—performing low evading, applying double leg takedown; counterattack to right low kick—cross or executing a double leg takedown; counterattack to right roundhouse kick—inside evading with displacement and applying left low kick; counterattack to left roundhouse kick—outside evading with displacement and applying right low kick, or applying a right spinning back kick or right back hook kick; or counterattack to double leg takedown—sprawl and knee strike, or already on the ground, move to the opponent's back and try to submit him/her with rear naked choke (Federação Portuguesa de Full Contact, 2018c) As mentioned above for counterattack execution, an previous base defense is used to avoid being hit and to create proper distance and posture (e.g. blocking, parrying, dodging, slipping, displacement, escape or jamming/ intercepting) (Federação Portuguesa de Full Contact, 2018c; Hao, 2019; Romashov, 2019; Wallace, 1982). These defensive actions should always be followed by counterattack, since if the fighter constantly blocks, he will eventually be hit (Forbes & Kolliopoulos, 2004; Urquidez, 1981). In fact, the counterattack performance requires seizing the opportunity in advance with adequate previous defense to counterattack, keeping an appropriate distance and balance, characteristic of expert fighters' actions (Hao, 2019; Ottoboni et al., 2015; Pinto, 2015).

Therefore, the counterattack performance is related to quick perception and anticipation (Asia & Sarkar, 2013; Borysiuk, 2008; Fontani Lodi Felici et al., 2006; Mori et al., 2002; Roi & Bianchedi, 2008; Rosalie & Muller, 2013; Vences Brito & Silva, 2011). Perception and situational analysis represent the ability to discern and predict the competitive constraints (Hucko & Desarrollo, 1981; Korcek, 1981), with cognitive decisions to anticipate the opponent's intentions accurately (Sagnol & Bisciotti, 1997) and attack or defend quickly, mainly identifying the emotions of the dynamic action (Shih & Lin, 2016). This is a quality that depends on quick interpretation of situational variability (Malkov & Romashov, 2018). In this sense, it becomes necessary to develop skills according to the variation in timing of the fighting actions (Malkov & Romashov, 2018). However, this is a quality associated with experienced fighters, since fighters develop action programs (ideomotor response model) (Malkov & Romashov, 2018). This is characterized by the cognitive development of quick perception, decision and

action, in advance of any stimulus (Parlebas, 1981) and effectively related to the tactical experience (Bayer, 1974; Meinel, 1984).

### **Defensive Efficiency**

Defensive efficiency and successful ground fighting control form a complex dynamic in ultimate full contact since there can be great variability in technical-tactical dynamics in both stand-up fighting and on the ground fighting.

Defence skills and ground fighting control are essential in combat sports. When a fighter attacks, the defense and fighting control skills must always be assured to avoid being hit by an eventual counterattack. This is a winners' characteristic (Adam & Sterkowicz-Przybycień, 2018; El Ashker, 2011). Thus, in addition to offensive actions, fighters must hone their defensive skills as an important fighting strategy (Forbes & Kolliopoulos, 2004). In fact, the best fighters have revealed efficiency in both offensive and defensive skills (Adam & Sterkowicz-Przybycień, 2018; Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2011). They combine offensive skills with defensive skills to be more efficient in the fight (Adam & Sterkowicz-Przybycień, 2018; El Ashker, 2011; Forbes & Kolliopoulos, 2004).

Defensive skills are technical-tactical actions that aim to protect the fighter from an offensive action. In ultimate full contact, some of the main defense skills are characterized by evading (dodging, slipping, displacements), jamming, parrying and blocking. Some of the main ground fighting control skills are characterized by mount, back control, side back control, close guard, side control, sweep, escaping, sprawling and immobilization.

Evading skills can be identified as the most appropriate to succeed in defensive actions since they avoid the impact and allow fighters to keep their hands or legs available to counterattack (Urquidez, 1981). They are a more complex skill, but their complexity is considered an advantage for fighting performance (Cular & Tomljanovic, 2011; El Ashker, 2011). Meanwhile blocking skills, for example, are more common defensive actions because of the simplicity of execution, but require the fighters to use both arms to cover them and absorb the impact of the opponent's strikes, therefore being unable to counterattack in advance (Urquidez, 1981). In addition, ongoing use of blocking can be damaging and a strike can pass the block, so it is recommended when using it to block and attack repeatedly (Urquidez, 1981). Authors agree that it is best to opt for evasion to avoid the impacts and be free to counterattack in advance; also, this way the fighter can adjust the distance and balance to counterattack more efficiently (Lee, 1975; Urquidez, 1981; Wallace, 1982).

In ground fighting, mount, back control, back side control or side control are skills associated with domination of opponents, allowing opponents to be overcome by striking (i.e., ground and pound) or submission skills (i.e., chokes and joint locks), (Adam et al., 2015; Del Vecchio et al., 2011). This is a dominant fighting strategy characteristic of winners, as shown in previous studies (Adam et al., 2015; Del Vecchio et al., 2011; Miarka et al. 2016). The abovementioned fighting strategies have been highlighted by the best fighters as relevant conditions to win (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska 2006; Kassim et al., 2015).

## **Video Analysis as an Essential Tool for Improving the Training and Strategic Process in Ultimate Full Contact**

It is known that the technical-tactical performance in competition is linked to the contextualized training practice (Barna, 2013; López-González, 2014; López-González & Miarka, 2013; Miarka et al., 2010). Several studies have been conducted through video analysis as an essential tool to understand the success of the best fighters and consequently improve the training process and fighters' performance (Atan & İmamoğlu, 2005; Badilin, 2014; Boguszewski, 2014a, 2014b, 2016; De la Fuente & Castejón, 2016; Del Vecchio et al., 2011; Dos Santos, 2019; Franchini & Del Vecchio, 2010; Franchini et al., 2008; Gierczuk & Bujak, 2013; James et al., 2017; Kalina, 2000; Kazemi et al., 2010; Miarka, 2016; Miarka et al., 2016; Santos et al., 2011; Wąsik et al., 2014). Thus, analysis of the technical-tactical and physiological demands of athletes in competition allows improve and contextualized/representative training to be carried out (Adam et al., 2016; Barna, 2013; Cipriano, 1993; López-González, 2014; López-González & Miarka, 2013; Miarka, 2016; Miarka et al., 2010), making it possible to adjust the training process according to the fighter's experience, age, gender, weight categories and fighting style (Slimani et al., 2017), and improving situational fighting strategies, and offensive and defensive effectiveness (Menescardi et al., 2019).

It has been stated that for the correct technical-tactical analysis, the contextualized training programs should be in accordance with the requirements and regulations of a specific combat sport, and so the observation has to be done through the modality concerned (Adam et al., 2016; Avakian, 2017; 2015; Miarka, 2016). Since the fighters have specific perceptual-motor performance profiles in distinct combat sports, the relationship between sensory and motor skills for action synchronization is different according to the sport's features (Chen et al., 2017). In addition, different regulations imply distinct technical-tactical dynamics (Menescardi et al., 2020). Accordingly,

preparation for combat sports with different rules needs an objective and exact assessment (Adam et al., 2011; Ito et al., 2015; Ito et al., 2013).

Effectively, the theoretical knowledge that can be conceived through practice and then scientifically analyzed is a determinant to develop the coach's skills in terms of training intervention, and consequently the performance of the fighters (Pinto, 2015). Training in accordance with the demands of competition allows the development of performance skills and regulates the physiological load intensity (Barna, 2013; Cipriano, 1993; López-González, 2011; López-González & Miarka, 2013), since fighting success depends on several contextual factors, such as technical, tactical, physical and psychological (Robles et al., 2016). Therefore, the importance of using analysis video observation to understand fighters' performance in the competitive context to improve the training process and, consequently, ultimate full contact fighters' performance is understandable.

In addition to the literature review, a review study was conducted.

## **Review Study**

### **Study 1 - Theoretical Basis of Technical-Tactical Behavior and its Application in Ultimate Full Contact Training**

#### **Abstract**

Technical-tactical training has been shown to be relevant to performance in a competition. In this regard, several studies have analyzed the efficiency of technical-tactical dynamics in combat sports. However, these researchers have mainly focused on technical efficiency, and therefore more research is needed regarding tactical efficiency. Furthermore, to the best of our knowledge, there are no published experiential studies on Ultimate Full Contact. Objective: this brief review will analyze the theoretical basis of technical-tactical behavior for training application in Ultimate Full Contact, characterizing the modality under cognitive and dynamic-ecological approaches. This knowledge can be transferred and applied to similar modalities, such as Pankration, Free Fight, Shooto, and Mixed Martial Arts (MMA). Conclusion: the theoretical technical-tactical knowledge created through competition is essential because it is the only way that improvements in the training process can occur. Ultimate Full Contact is characterized as combat sport of special complexity and intermittent intensity, where the technical-tactical factors are decisive for the performance while the physical component can be a conditioning factor. A careful regulation between technical-tactical training load and physiological load is essential to obtain adjustable adaptations. Both cognitive and dynamic-ecological approaches should be considered based on the respective training models.

**Keywords:** Combat sports; ultimate full contact; pankration; mma mixed martial arts; free-fight; technical-tactical; cognitive and dynamic-ecological approaches; training methods; styles; combat distances

## **Problem Definition**

Ultimate Full Contact was established in 1988 by the World Ultimate Full Contact (WUFC). It is a combat art with a special complexity based on Pankration and it has been significantly influenced by taekwondo, boxing, Muay Thai, American full contact, kickboxing, sambo, Jiu jitsu and wrestling (Federação Portuguesa de Full Contact [FPFC], 2018a, 2018b; Pinto, 2015). It resembles Mixed Martial Arts (MMA) (i.e., modality developed from vale tudo), which is also composed of striking and submission grappling actions (Del Vecchio, Hirata, & Franchini, 2011; Miarka, Brito, & Amtmann, 2017; Slimani, Davis, Franchini, & Moalla, 2017; Tabben, Miarka, Chamari, & Beneke, 2018), with specialized techniques from traditional combat styles (Miarka, 2016). Ultimate Full Contact is characterized as an intermittent sport in terms of technical-tactical and energetic resources, which combines stand-up fighting with ground fighting (Federação Portuguesa de Full Contact, 2018a, 2018b; Pinto, 2015). The fights are developed under the context of high variability, unpredictability and tenacity with high volitional effort due power strikes and takedowns of great amplitude, where the knockout (KO) may happen at any moment (Federação Portuguesa de Full Contact, 2018b; Pinto, 2015). In this context, in addition to performance constraints (i.e., physical, psychological, socio-affective), technical and tactical capacities are determinants and are decisive in performance (Federação Portuguesa de Full Contact, 2018b; Pinto, 2015). In fact, according to the literature, in complex sports such as combat sports or collective sports, it is only through technical-tactical training that all other skills are developed (Castelo et al., 1996). Furthermore, a previous research with fighters and coaches from different martial arts and combat sports (i.e., full contact, taekwondo, boxing, ultimate full contact, pankration, free-fight, MMA, wrestling, judo, Muay Thai, karate, Jiu jitsu) has highlighted that technical-tactical skills and psychological capacities are the most important dimensions for performance (Pinto, 2015). In addition, it is known that the technical-tactical performance in competition is linked to contextualized training practice (Barna, 2013; López-González, 2014; López-González & Miarka, 2013; Miarka, Julio, Del Vecchio, Calmet, & Franchini, 2010). Therefore, the theoretical knowledge that is acquired through practice and then scientifically analyzed is a determinant means to develop the coach's skills and the fighter's performance, improving the scientific-training intervention and the fighter's development (Pinto, 2015). Observation of the fighter's dynamics in competition is recommended because it allows us to obtain representative knowledge for contextualized practices (Boguszewski, 2014; Coswig, De Paula, & Del Vecchio, 2016; Coswig, Hideyoshi, De Paula, & Del Vecchio, 2016; De la Fuente & Castejón, 2016; Del Vecchio et al., 2011; Kalina et al., 2004; Karpman, Reid, Phillips, Qin, & Gross, 2016;

Miarka et al., 2017; Miarka, Cury, Julianetti, & Battazza, 2014; Miarka, Vecchio, Camey, & Amtmann, 2016; Santos, Franchini, & Lima-Silva, 2011). However, the literature describes that technical-tactical analysis determines references for contextualized training programs that are adapted to the requirements and regulations of a specific combat sport (Adam, Klimowicz, & Pujszo, 2016; Avakian, Miarka, & Achour, 2017; Miarka, 2016). In fact, the fighters have been shown to have different profiles of perceptual-motor performance in distinct combat sports (Chen et al., 2017), even in the same modality, while the regulations modifications imply distinct technical-tactical dynamics (Menescardi, Falco, Hernández-Mendo, & Morales-Sánchez, 2020). In this reasoning, it is understandable that (for example) trying to make a armlock in a context where only submission grappling is allowed is very different from a context where it is also allowed to strike; or punching when the rules allow only punching is very different if the rules also allow kicking or grappling. In addition, most of the current technical-tactical studies in combat sports result from modalities of different characteristics, whose competitions rules allow a restricted number of skills when compared to Ultimate Full Contact, such as in Olympic taekwondo WT (World Taekwondo) where essentially leg techniques are used; in boxing where only punches are allowed; in kickboxing, karate, and taekwondo ITF (International Taekwondo Federation) where only punches and kicks techniques are authorized; or in wrestling, judo, and Jiu jitsu, where only submission grappling skills are allowed. Consequently, the preparation for different competitive rules requires an objective and specific assessment (Adam, Smaruj, Tyszkowski, 2011; Ito et al., 2013; Ito, Hirose, Tamura, & Nakamura, 2015). Although review concerning to technical-tactical dynamics in the Ultimate Full Contact is necessary, through a previous research it was understood that experiential studies are not published. Consequently, this review adopted an inclusion criterion that considers studies carried out in similar modalities (i.e., hybrid full contact combat sports) or in other full contact combat sports studies with great focus on the present investigation. The present review highlights the technical-tactical performances in hybrid combat sports. It is also our intention to know more about cognitive and dynamic-ecological approaches that are associated with combat sports. To search for relevant publications, the main databases were used (e.g., Web of Science, Scopus, and PubMed). Articles published in all years and in English, Spanish or Portuguese were considered. Primary keywords were used to search (“combat sports” or “martial arts”) with a second keyword (“ultimate full contact”, “pankration”, “free-fight”, “mma mixed martial arts”, “shooto”, vale tudo) and a third keyword (“technical-tactical”, “cognitive”, “dynamic-ecological”, “skills”, “fighting outcome”, “distances”, “offensive”, “defensive”, “counteroffensive”, “attack”, “counter-attack”, “styles”). All articles without a focus on

the investigation were excluded. In total, 43 articles were considered to be relevant. However, only 16 articles specifically analyze technical-tactical dynamics in hybrid combat sports, especially in MMA.

### **Summary of Previous Research**

Previous investigations that analyzed the technical-tactical performance help to understand the success of the best fighters (James, Robertson, Haff, & Kelly, 2017; Santos et al., 2018) because the development of technical and tactical capabilities maximizes success in competition (Bello, Brito, Amtmann, & Miarka, 2019). However, the physiologic approach can be a conditioning factor for technical-tactical functionality, especially regarding the variation in the intensity of fights (Amtmann, 2004; Amtmann, Amtmann, & Spath, 2008; Chernozub, Korobeynikov, Bogdan, & Korobeinikova, 2018). It is known that striking is more associated with high-intensity regime with an alactate or lactate energy supply power system, while in contrast submission grappling is more associated with low-intensity regimes with glycolytic power supply system (Chernozub et al., 2018). Therefore, the necessity to regulate the load of technical-tactical training with the physiological load to obtain adjustable adaptations, combining and articulating single techniques with combinations techniques becomes clear. This is a set of varied and differentiated skills that must remain interrelated as one of the basic conditions in combat (Kirk, Hurst, & Atkins, 2015), with the aim to dominate the opponent through offensive, counteroffensive and defensive actions, searching for the fight outcome by knockout KO, technical knockout TKO, submission or decision (Federação Portuguesa de Full Contact, 2018b; Pinto, 2015). The analysis of technical-tactical actions can help us to understand their different effect on the outcomes, and this way regulate their application through the fights (Gronek, Wielinski, & Gronek, 2015; Maszczyk et al., 2018; Miarka, Coswig, Brito, 2016). In addition, the fight outcomes are related with contextualized practices (Miarka, Coswig, et al., 2016). Thus, the fight outcome by KO/TKO and submission are more related with striking and grappling actions during ground fighting, while outcomes by decision are more related to stand-up striking (Miarka, Coswig, et al., 2016). In other studies, analyzing only grappling style in combat, it is reported that the fight outcomes by KO/TKO, submissions, or score decisions (i.e., unanimous and split) demonstrated technical-tactical pattern. In particular, grappling showed lower frequency attempts with KO/TKO, ground grappling showed higher frequency attempts related with submission outcomes, while stand grappling showed higher frequency attempts related with score decisions. (Bello et al., 2019). This seems to indicate that

different styles are adopted by the fighters and that this may have an influence on the outcome of the fight.

However, successful motor actions require accurate motor control to promote fast adaptations to spatiotemporal variations, and to maintain distances and control over the opponent with anticipated and adjusted attacks with increased frequency (Del Vecchio et al., 2011; Miarka, Brito, Del Bello, & Amtmann, 2017). In fact, the winners showed a higher frequency of strikes, submission, and positional improvements over the losers, as well more self-regulation actions through the rounds, with a significantly increase of submission and strangulation attempts at the last round, which gives them high control over the losers. (Miarka, Vecchio, et al, 2016). In this field, the striking combinations should be used at the distance. During the clinch, the attacks must be combined with takedowns. In particular, if the fighter is at a disadvantage in the stand-up fighting to his opponent, then he must keep in ground fighting, attempting to end the fight by submission techniques, preferably by choke skills (Miarka et al., 2017). At a distance, the fighters use free movements/actions without grips, where the skills are characterized by full contact strikes (i.e., kicking, punching, knee and elbow striking) (Amtmann, 2004; Amtmann et al., 2008; Chernozub et al., 2018; Dal Bello et al., 2019; Gronek et al., 2015; James et al., 2017; Kirk et al., 2015; Kruyning & De Jong, 2014; Maszczyk et al., 2018; Miarka, Brito, Dal Bello, et al., 2017; Miarka, Coswig, et al, 2016). In fact, there is a high technical variability, where strikes must be powerful and precise without being exposed to the opponent (Miarka, Brito, & Amtmann 2017). At clinch and ground combat, the fighters use submission grappling skills (i.e., grips, takedowns, chokes and joint locks) (Kruyning & De Jong, 2014; Pinto, 2015), and ground striking (i.e., ground and pound) (Adam, Pujszo, Stanisław, Szymański, & Tabakov, 2015). The decision-making by stand-up fighting or ground fighting is a tactical characteristic that depends on the fighter or the context (Antonietto et al., 2019; James et al., 2017; Maszczyk et al., 2018). This consists of an interaction individual-context, which refers to the interrelation between the fighter and the environment, to act in accordance the opportunities (i.e., affordances) (Gibson, 1979). These opportunities result from the interaction of both fighters as a dynamic-ecological approach. The fighters perceive the opportunities to attack or defend into one interpersonal synergy, and success depends on the ability of their actions to take advantage of the context instability or stability (Krabben, Orth & Van der Kamp, 2019). However, a review by the same author (Krabben et al. 2019), reported that it is the expert fighters who can accurately perceive the limits of action (Krabben et al., 2019). In addition, the perceptual-cognitive expertise to quickly perceive, interpret and act in advance (i.e., anticipation) to the opponent's actions is a fundamental skill in combat

sports (De Quel & Bennett, 2019). This facility to capture information is more likely to be found in expert fighters (De Quel & Bennett, 2019). In fact, a general superiority of perceptual-cognitive skills is demonstrated by the expert fighters (Russo & Ottoboni, 2019). This is in line with the cognitive tactical reasoning, where the experience obtained through repeated practice is a fundamental factor to improve the fighter's perception, accurate technique, and decision-making (Castelo et al., 1996; Mahlo, 1997). Systematic repetition automates the actions, works the memory, and increases the capacity of perception and discernment for correct decision-making and precise actions (Mahlo, 1997). In this sense, the technical development is based on the evolution of coordination capacity, which requires a pedagogical progression in coordinative complexity as a recommended method for its efficiency (Bolotin & Bakayev, 2018; Pinto, 2015). In fact, the hybrid combat sports, such as Ultimate Full Contact, are characterized by a special complexity and they require a high degree of cognitive processing under volitional effort to make appropriate decisions from numerous possible resources, and to define strategies and distances in search of opportunities to attack and counterattack with precision and power (Pinto, 2015). This appropriate decision-making requires a perceptual-cognitive expertise to enable the fighters to perceive and act accordingly (i.e., perception-action), considering the fighting distance, attack progression, and the opponent's reactions (De Quel & Bennett, 2019).

### **Conclusion and Training Suggestions**

Technical-tactical studies in specific hybrid combat sports are scarce or even nonexistent (e.g., Ultimate Full Contact, Pankration, Free Fight, Shooto, Vale Tudo, and MMA), and the few that exist were developed in MMA. However, tactical abilities such as fighting distances, fighting styles and the development of offensive, counteroffensive and defensive dynamics require further investigation given their importance for performance during the fight. In this review, the technical-tactical theoretical basis of Ultimate Full Contact has been identified as a hybrid combat sport of special complexity and intermittent structure in technical-tactical and physiological aspects, combining single actions with combination actions of different intensities. These are a set of variety technical-tactical actions that aim to overcome the opponent. The fights take place in contexts of high unpredictability, variability, and tenacity, with stand-up fighting and/or ground fighting, where fighters are characterized by stand-up-strikers, ground strikers and submission grapplers, according to their techniques and tactical behaviours. A stand-up fighter is one who keeps the distance (long or short) using extent full contact strikes (i.e., kicks and straight punches—jab, cross and back

fist) or short strikes (i.e., knees, elbows and short punches—hooks and uppercuts); the ground strikers and submission grapplers are those who keep the close distance with clinch and grips, aiming to takedown the opponent and end the fight using chokes, joint locks, or ground and pound, respectively.

To be successful in combat, the ultimate full contact fighters need to develop a high and varied technical-tactical repertoire and qualities in their actions, such as anticipation, quick perception and interpretation, spatiotemporal-synchronization and adaptation, adequate decision-making, automation, context adaptability, timing, seizing opportunities, unpredictability, distance measurement, balance, displacements, efficiency, precision and power.

We suggest that the training process should be developed based on the cognitive and dynamic-ecological models because this will ensure that the combat actions are safe, correct, adequate, precise and at the same time spontaneous, representative and creative (e.g., intercalate analytical and integrated training methods through systematic technical-tactical repetitions one-to-one and formal or limited and fractional sparring). According to the literature, in complex sports such as combat sports or collective sports, technical-tactical training enables all other skills to be developed (i.e., physical, psychological and socio-affective). Consequently, the load of technical-tactical training should be regulated with the physiological load to obtain adjustable adaptations (e.g., practice technical exercises under interval or intermittent training).

It is also important to highlight that the ultimate full contact training is a complex process, transversal coach-athlete, that is guided by scientific principles (i.e., methodological, biological, and pedagogical). Thus, the theoretical basis of technical-tactical behavior is essential and useful information for coaches who wish to optimize their methodologies, intervention capacity, and who wish to give feedback to improve the fighter's performance.

### **Suggestions for Further Research**

To create a new trend of investigation, and to respond to the gaps identified in the literature, future research may focus on better understanding the technical-tactical behavioral dynamics. Consequently, we suggest to analyze that the fighter's behaviours in the competitive contexts of Ultimate Full Contact (i.e., efficiencies of long distance, short distance, close distance related with styles stand-up striker, ground striker, submission grappler; attacks preparation or counter-attacks related with its time responses; fights outcomes methods; offensive dynamic efficiency, counteroffensive dynamic efficiency and defensive dynamic efficiency). These technical-tactical demands

can help to develop technical-tactical fighting strategies in Ultimate Full Contact. They are also useful for coaches who wish to create training programs and exercises to optimize the fighter's performance. In addition, the results of these suggested studies will be based on specific and representative knowledge obtained through a hybrid combat sport, which will be able to be extrapolated to similar modalities (e.g., Pankration, Free-Fight, Shooto or MMA).

## **Chapter 3. Observational Studies**

### **Study 2 - Ultimate Full Contact offensive efficiency analyzed through styles and combat distances: a confluence of cognitive and ecological approaches**

#### **Abstract**

Background & Study Aim: Ultimate Full Contact is a hybrid combat sport where offensive efficiency takes on an important role during a fight. However, to the best of our knowledge, no study has investigated the impact of offensive efficiency based on combat style and distances. Thus, the study aimed to investigate the offensive efficiency related to distances, styles, skills and their interrelationships during combat. Materials and Methods: 170 fight DVDs were observed, integrating (n= 340) senior male athletes who participated in the WUFC World Championships. Technical-tactical attacks made and effective, between winners and losers, with different combat styles and distances were they used to analyze the difference between winners and losers and different combat styles, through the Kalina method for the offensive efficiency, Mann-Whitney U and Spearman's bivariate correlation. Results: The results indicate that winners had significant advantage in all offensive skills regarding the different combat distances and styles. Generally, striking skills were more efficient than submission grappling. Higher correlations were shown between specific distances and specific styles. Conclusions: The winners attacked more and more effectively and showed greater efficiency, stability, versatility, adaptability and opportunity seizing. The biggest difference of winning or losing effect depends mainly on ground fighting, however it is supported by the efficiency of stand-up fighting (takedowns, punching and kicking). It is not enough to react spontaneously according to the contextual opportunities without cognitively perceiving, interpreting and deciding on specific and certain actions at the right time, articulating styles with distances.

**Keywords:** combat sports; ground fighting; technical-tactical skills; stand-up fighting; dynamics; attack; versatility; adaptability; opportunity

## **Introduction**

Ultimate Full Contact is a combat sport of extreme complexity, given the variety of dynamic technical-tactical actions that can be performed (offensive, counteroffensive and defensive) (Pinto, 2015). These actions are developed in Stand-up Fighting and/or Ground Fighting, under conditions of high tenacity, variability and unpredictability, which require high cognitive and physiological processes (Pinto, 2015). During the fight, the main objective is to avoid suffering blows, through dodges/slips, displacements, immobilizations, blocks, parries or reversing the opponent's dominant positions (Pinto, 2015). In addition, it is essential to make the greatest number of strikes (i.e., punches, knees or kicks) in the opponent's anatomical regions, in order to score, weaken, knockout or take them down and finish by submission techniques (chokes, locks) or ground and pound (Pinto, 2015).

Previous investigations into fighting dynamics in combat sports have concluded that the winners are usually characterized by manifesting greater offensive activity and consequently carrying out more offensive actions (i.e., Attack Effectiveness or Offensive Efficiency), which is one of the main distinguishing aspects of fight winners (Boguszewski, 2014a, 2014b; 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2011; Koropanovski, Dopsaj, & Jovanović, 2008; Koroponovski & Jovanović, 2007; Wąsik, Pieter, & Borysiuk, 2014); their efficiency is usually characterized by the ratio of scored attacks to the total number of offensive actions, which means that the higher the ratio, the better the offensive efficiency (Kalina, 2002; Kalina, Kulesza, & Mysłowski, 2004).

Thus, the offensive efficiency requires certain qualities to deliver a fast and accurate attack, such as good footwork and balance, distance control, strategic analysis and fluid movement around the opponent (Lee, 1975; Urquidez, 1981). The attack must be carried out at the proper time, automatically, quickly and be unpredictably (Lee, 1975). In this field, the importance of giving few indicators of the following attack movements is highlighted, so that the opponent will always have more difficulty in predicting the attack, until it is impossible to stop it (Wallace, 1982). At the same time, integrated quick punches and the ability to close or evade with speed, spontaneously produces an infinite number of techniques and combinations in mathematical progression, keeping the opponent always on the defensive (Wallace, 1982). This makes it possible to keep control of the combat, enabling the taking of the initiative without restrictions, with combined and quick attacks (Wallace, 1982). Also, greater skills knowledge and versatility (i.e., striking and grappling techniques) as well as the frequency of linking together technical actions and ground control are important qualities in the offensive

action that the winners had shown at Full Contact and Mixed Martial Arts (Adam, Pujso, Stanislaw, & Szymanski, 2015; Urquidez, 1981).

However, distance control is very important; the proper distance is safe when a fighter overcomes the opponent, and it depends on the speed, agility and the ability to synchronize changing distances and diversified technical-tactical actions (Lee, 1975). Thus, the fight distance is related to continual shifting of displacements between opponents, looking for the most appropriate defense and attack position. This requires a cognitive stability and adaptation to different contexts (Pinto, 2015).

Furthermore, in a fight, each athlete competes according to his or her own style and to their most comfortable combat distance using a cognitive process immediately linked to different combat schemes according to the objectives (Pinto, 2015). Experience is a relevant factor to manage offensive actions successfully, developing a self-improvement motor skills programmed and the perceptive and interpretive ability to discern possible opponent counter-attacks and defenses (Mahlo, 1997; Pinto, 2015). In addition, the offensive tactical-technical action requires a perfect execution at the right time (timing) considering the planned and intentionally spontaneous actions with their respective slow and fast patterns (Keller & Tyshler, 1972; Malkov & Ramashov, 2019). In fact, the situational efficiency depends on the ability to perform several structures of motion, in different manners and from variable distances (Vidranski, Maškarin, & Jukić, 2015). Thus, the variability (e.g., change rhythm) and transience (e.g., change complexity) limit the time to decide properly, requiring perception and anticipation skills (Castelo et al., 1996). Therefore, perception and anticipation ability appear to be important attributes for performance in combat sports, and their development allows adaptive motor skills with maximum effectiveness for multiple and divergent competitive situations (Milazzo, Farrow, & Fournier, 2016; Pinto, 2015; Shih & Lin, 2016; Silva, Del Vecchio, Picanço, & Takito, 2011). In addition, divergent contextual perception is fundamental, allowing the fighter to act effectively in any style or combat distance using certain specific techniques, acting spontaneously and appropriately at the exact moment (Fajen, Rille, & Turvey, 2008; Hristovski, Davids, Araújo, & Button, 2006). Therefore, the decision and the action derive from an individual–context interaction. Thus, based on ecological dynamic reasoning (Araújo, 2005), it can be said that the variability in the course of action may have its origin in the individual (e.g., choosing to fight standing when he only has a rudimentary tactical ability in ground fighting behavior while fighting on the ground – submission / grappling) or in the context (e.g. choosing to fight standing when the opponent is known to be strong tactically in ground fighting).

Thus, it seems important that information is obtained based on the observation of the fighters' performance in a competitive context, since an analysis of the real situation reveals a representative knowledge to the contextualized practices in training (Adam et al., 2015; Araújo, 2006; Araújo & Davids, 2011; Araujo, Davids, & Hristovski, 2006; Bocioaca, 2014; Boguszewski, 2016; Boguszewski & Boguszewska, 2006; Davids, Araújo, Correia, & Vilar, 2013; De la Fuente & Castejón, 2016; Miarka, Fukuda, Del Vecchio, & Franchini, 2016; Pityni, Okopnyy, Tyravskys, Hutsul, & Ilnytsky, 2017; Silva et al., 2014; Sterkowicz-Przybycień, Miarka, & Fukuda, 2017; Travassos, Duarte, Vilar, Davis, & Araújo, 2012; Travassos, Gonçalves, Marcelino, Monteiro, & Sampaio, 2014). Therefore, considering the lack of studies that address this topic specifically in Ultimate Full Contact, more research is needed. Previous investigations have reported on offensive efficiency in modalities such as judo, tae kwon do, karate or boxing (Boguszewski, 2014a, 2014b; 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2011; Kalina, 2002; Kalina et al., 2004; Koropanovski et al., 2008; Koroponovski & Jovanović, 2007; Wąsik et al., 2014;), which require a limited number of techniques when compared to Ultimate Full Contact (Pinto, 2015), and therefore make the results unrepresentative for the modality under analysis. The importance and functionality of the technique vary depending on the sports characteristics, athletes and contexts (Peixoto, 1997). In addition, the studies presented focus only on the relationship between effective techniques and the techniques performed, disregarding the actions taken according to the environment and behaviours, such as the distances and styles adopted by the fighters.

Therefore, this study aims to characterize the offensive efficiency according to the winners and losers, relating their effective attacks to attacks made through the different styles, their specific offensive technical-tactical actions and different combat distances. In addition, this study aims to compare the differences in offensive efficiency according to styles and combat distances in relation to the win or lose effect, as well as comparing the efficiencies of distance with the efficiencies of style and the fighters' specific actions in order to analyze the gestural and behavioral actions from a cognitive (McPherson, 1994; Gréhaigne, & Godbout, 1995; Williams, Ford, Eccles, & Ward, 2011) and ecological dynamics perspectives (Araújo, 2006; Araujo, Davids, & Hristovski, 2006; Silva, Garganta, Araújo, Davis, & Aguiar, 2013; Vilar, Araújo, Davids, & Button, 2012).

## **Material and Methods**

### **Subjects**

Three hundred and forty senior male athletes participated (master class – minimum level of national champions or high grade in their styles, aged  $\geq 18$ , and from all weight divisions), representing 38 countries, and comprised 170 (50.0%) winners and 170 (50.0%) losers who had participated in the WUFC Ultimate Full Contact World Championship, held annually in Portugal between 2008 and 2017. These athletes were chosen because they are the elite athletes in the world according to the WUFC world rankings (World Ultimate Full Contact [WUFC], 2019).

From the 170 fights analyzed in Ultimate Full Contact under professional rules, the total time was 43,120" ( $253.65 \pm 203.65$ ), of which 84 (49.4%) ended by submission, 33 (19.4%) by decision, 33 (19.4%) by technical knockout, 18 (10.6%) by knockout and 2 (1.2%) by doctor stoppage.

### **Instruments and procedures**

The methodology used was based on the Kalina method for combat dynamics analysis, considering the offensive efficiency index (i.e., the ratio between effective techniques to the techniques used) (Kalina, 2002; Kalina et al., 2004). Adaptations to the protocol were made in order to also obtain the efficiency of the tactical behavior in the different styles and distances of fighting, as well as its impact on winning or losing. In addition, the study also sought to identify the correlation intensities between the distances, styles and their characteristic actions, which is in accordance with the approach of specific actions according to the different perceived distances (Hristovski et al., 2006).

Observation grids were created in Microsoft's Excel Office 365 software, where all technical and tactical and effective actions made by the winning (W) and losing (L) athletes were recorded. Therefore, the 170 Ultimate Full Contact fights on the DVDs, provided by World Ultimate Full Contact, were observed. A total of 4602 ( $13.54 \pm 13.02$ ) attacks were made and 1835 ( $5.40 \pm 5.36$ ) effective attacks were reported, of which 1931 ( $11.36 \pm 10.87$ ) were made by losers with 455 ( $2.68 \pm 3.00$ ) effective, and 2671 ( $15.71 \pm 14.58$ ) by the winners with 1380 ( $8.12 \pm 5.80$ ) effective.

The various technical-tactical actions were grouped, according to their characteristic, by the different combat dynamics with the following WUFC terminology: Styles (e.g. Submission Grapplers (SG)) – Takedowns, Locks, Chokes; Stand-Up Strikers (SUS) – Kicks, Knee Strikes, Punches; Ground Strikers (GS) – Takedowns, Ground and Pound; and Distances (e.g. Long Distance (LD); Short Distance (SD); Close Distance (CD)).

The study was performed in accordance with the Declaration of Helsinki and maintains the anonymity of the players according to European data protection law. The ethical approval for this study was obtained from the local ethics committee.

## **Statistical analysis**

The Kolmogorov–Smirnov test was used to verify the normality of the sample and revealed no normal data distribution. Thus, offensive efficiency variables were analyzed using non-parametric Mann-Whitney U statistical tests to identify the difference in the efficiency of winning or losing due to the effect of all variables. Spearman's bivariate correlation was used to correlate the total values (winners and losers) of the distance efficiency with the efficiency of the styles and their characteristic actions. The relationship intensities between the variables were interpreted according to the correlation scale: i) Very weak and insignificant correlation ( $r \leq 0.19$ ); ii) Weak correlation ( $0.2 \leq r \leq 0.39$ ); iii) Moderate correlation ( $0.4 \leq r \leq 0.69$ ); iv) Strong correlation ( $0.7 \leq r \leq 0.89$ ); v) Very strong correlation ( $0.9 \leq r \leq 1$ ) (Cohen & Holliday, 1982). In the correlations, the significance of  $p < 0.01$  and  $p < 0.05$  were determined.

## **Results**

Table 1 shows the descriptive statistical data from the offensive efficiency variables in relation to the winning and losing athletes. These variables were the result of the ratio between the total effective offensive actions and the offensive actions made, according to the respective distances, styles and subgroups of specific technical-tactical actions of each style. The averages (Av) show that there was an advantage of the winners over the losers in all variables of offensive efficiency (Table 1). That means the winners are more versatile and adaptable to different contextual situations. Statistically significant differences in all combat dynamics were observed between winners and losers ( $p < 0.01$ ) (Table 2). The overall Offensive Efficiency between the two groups was (60.12 and 25.58, respectively) (Table 1). This determined that the winners demonstrated significantly higher effectiveness of attack than the losers, with a statistically significant difference, with  $U = 3920.00$  and  $p = 0.000$ .

When analyzing the Offensive Efficiency according to combat Styles, the greatest efficiency and difference between winners and losers was recorded in the Submission Grappler (66.93 and 36.78;  $U = 6239.50$ ;  $p = 0.000$ ) followed by the Ground Striker Efficiency (65.51 and 26.87;  $U = 7362.00$ ;  $p = 0.000$ ) and Stand-Up Striker Efficiency (46.36 and 21.30;  $U = 7373.50$ ;  $p = 0.000$ ) (Tables 1 and 2). Thus, it was demonstrated that ground fighting is more efficient than stand-up fighting, and also the winning or losing effect depends more on the ground fighting styles (Submission Grapple and Ground Striker). However, the data also confirmed that the same fighters (winners) who were more efficient in the ground fighting, were also more efficient in the stand-up fighting.

Through a comparison of the Offensive Efficiency between winners and losers according to the technical-tactical actions specific to each style, the following were determined as the most efficient variables of specific actions, in descending order: SG Takedowns Efficiency, GS Ground & Pound Efficiency, SUS Kicks Efficiency, SUS Punches Efficiency, SG Chokes Efficiency, SUS Knees Efficiency, SG Joint Locks Efficiency (Table 1). The biggest differences in these variables of winners and losers, significantly in favor of the winners, were recorded in descending order: SG Takedowns Efficiency, GS Ground & Pound Efficiency, SUS Punches Efficiency, SG Chokes Efficiency, SUS Kicks Efficiency, SUS Knees Efficiency, SG Joint Locks Efficiency (Table 2). With regard to the fight endings by SG Chokes and Joint Locks, these were constant (0) and were omitted by the losers, since these technical-tactical efficiency actions result in winning the fight by submission. These data seem to indicate that the winners use a great versatility of technical-tactical actions, alternating higher efficiency of ground fighting with stand-up fighting skills.

Through the analysis the Offensive Efficiency according to the different combat distances it was observed that the winners exceeded their opponents in all ranges. The efficiency of attack and its difference between the fighters' groups were determined in descending order: Close Distance, Long Distance and Short Distance (Tables 1 and 2). The winners demonstrated significantly higher effectiveness of attack over all distances. These results seem to indicate that the winning or losing effect clearly depends on the offensive efficiency. This was a characteristic of the winners at all levels of offensive styles, skills and distances, showing higher technical-tactical versatility and situational/contextual adaptation.

**Table 1.** Descriptive data of fight distances efficiency, styles efficiency and its technical tactical actions efficiency

| Variables                               | Winners (n=170) |           |           |            | Losers (n=170) |           |           |            |
|---|-----------------|-----------|-----------|------------|----------------|-----------|-----------|------------|
|   | <i>Av</i>       | <i>SD</i> | <i>Me</i> | <i>IQR</i> | <i>Av</i>      | <i>SD</i> | <i>Me</i> | <i>IQR</i> |
| <b>Overall Offensive Efficiency</b>     | 60.12           | 21.11     | 59.41     | 28.39      | 25.58          | 24.25     | 20.00     | 35.23      |
| <b>Long Distance Efficiency</b>         | 44.52           | 31.63     | 48.08     | 44.44      | 20.52          | 25.68     | 13.39     | 33.33      |
| <b>Short Distance Efficiency</b>        | 30.83           | 39.65     | .00       | 66.67      | 9.66           | 24.56     | 0.00      | 0.00       |
| <b>Close Distance Efficiency</b>        | 67.17           | 31.29     | 67.71     | 50.00      | 22.17          | 33.38     | 0.00      | 40.71      |
| <b>Submission Grappler Efficiency</b>   | 66.93           | 35.99     | 75.00     | 50.00      | 23.57          | 36.78     | 0.00      | 44.64      |
| <b>Stand Up Striker Efficiency</b>      | 46.36           | 30.13     | 48.68     | 41.67      | 21.30          | 24.77     | 15.69     | 33.33      |
| <b>Ground Striker Efficiency</b>        | 65.51           | 37.52     | 76.39     | 50.00      | 26.87          | 38.21     | 0.00      | 52.50      |
| <b>SG Takedowns Efficiency</b>          | 64.89           | 43.55     | 100.00    | 100.00     | 29.40          | 42.80     | 0.00      | 70.00      |
| <b>SG Chokes Efficiency</b>             | 31.23           | 44.42     | 0.00      | 100.00     | a              | a         | a         | a          |
| <b>SG Joint Locks Efficiency</b>        | 12.84           | 33.14     | 0.00      | 0.00       | b              | b         | b         | b          |
| <b>SUS Punches Efficiency</b>           | 33.91           | 34.47     | 29.73     | 57.14      | 11.08          | 20.63     | 0.00      | 16.67      |
| <b>SUS Kicks Efficiency</b>             | 43.18           | 39.97     | 46.61     | 78.93      | 23.29          | 33.11     | 0.00      | 36.65      |
| <b>SUS Knees Efficiency</b>             | 21.00           | 37.46     | 0.00      | 29.76      | 6.72           | 22.78     | 0.00      | 0.00       |
| <b>GS Takedowns Efficiency</b>          | 64.89           | 43.55     | 100.00    | 100.00     | 29.40          | 42.80     | 0.00      | 70.00      |
| <b>GS Ground &amp; Pound Efficiency</b> | 50.06           | 44.13     | 52.78     | 100.00     | 7.30           | 24.21     | 0.00      | 0.00       |

**a**= Style submission grapplers choke efficiency is constant. It was omitted; **b** = Style submission grapplers joint lock efficiency is constant. It was omitted; **SG** = Submission Grappler; **SUS** = Stand-Up Striker; **GS** = Ground Striker.

**Table 2.** Mann-Whitney test effectuated between winners and losers, in the different variables of offensive efficiency

| <b>Variables</b>                        | <b>Winners (n=170)</b> |                     | <b>Losers (n=170)</b> |                     | <b>Mann-Whitney U</b> | <b>p-value</b> |
|---|------------------------|---------------------|-----------------------|---------------------|-----------------------|----------------|
|   | <i>Mean Rank</i>       | <i>Sum of Ranks</i> | <i>Mean Rank</i>      | <i>Sum of Ranks</i> |                       |                |
| <b>Offensive Efficiency</b>             | 232.44                 | 39515.00            | 108.56                | 18455.00            | 3920.00               | .000           |
| <b>Long Distance Efficiency</b>         | 208.92                 | 35516.50            | 132.08                | 22453.50            | 7918.50               | .000           |
| <b>Short Distance Efficiency</b>        | 195.30                 | 33201.50            | 145.70                | 24768.50            | 10233.50              | .000           |
| <b>Close Distance Efficiency</b>        | 224.67                 | 38194.50            | 116.33                | 19775.50            | 5240.50               | .000           |
| <b>Submission Grappler Efficiency</b>   | 218.80                 | 37195.50            | 122.20                | 20774.50            | 6239.50               | .000           |
| <b>Stand Up Striker Efficiency</b>      | 212.13                 | 36061.50            | 128.87                | 21908.50            | 7373.50               | .000           |
| <b>Ground Striker Efficiency</b>        | 212.19                 | 36073.00            | 128.81                | 21897.00            | 7362.00               | .000           |
| <b>SG Takedowns Efficiency</b>          | 204.72                 | 34802.50            | 136.28                | 23167.50            | 8632.50               | .000           |
| <b>SG Chokes Efficiency</b>             | 200.50                 | 34085.00            | 140.50                | 23885.00            | 9350.00               | .000           |
| <b>SG Joint Locks Efficiency</b>        | 182.00                 | 30940.00            | 159.00                | 27030.00            | 12495.00              | .000           |
| <b>SUS Punches Efficiency</b>           | 202.12                 | 34360.50            | 138.88                | 23609.50            | 9074.50               | .000           |
| <b>SUS Kicks Efficiency</b>             | 193.07                 | 32822.00            | 147.93                | 25148.00            | 10613.00              | .000           |
| <b>SUS Knees Efficiency</b>             | 186.14                 | 31644.00            | 154.86                | 26326.00            | 11791.00              | .000           |
| <b>GS Takedowns Efficiency</b>          | 204.72                 | 34802.50            | 136.28                | 23167.50            | 8632.50               | .000           |
| <b>GS Ground &amp; Pound Efficiency</b> | 214.39                 | 36446.00            | 126.61                | 21524.00            | 6989.00               | .000           |

**Note:** SG = Submission Grappler; **SUS** = Stand-Up Striker; **GS** = Ground Striker.

## Comparison between the distance efficiencies with the style efficiencies

Table 3 shows, by total values (i.e., winners and losers), a strong and significant relation with positive direction between the Long-Distance efficiency and the SUS style efficiency ( $r_s = 0.898$ ;  $p < 0.01$ ), while this distance efficiency with the styles SG and GS presented respectively very weak and weak correlations. With regard to the Short-Distance efficiency, there was a moderate positive and significant correlation with SUS style ( $r_s = 0.444$ ;  $p < 0.01$ ), and positive with GS and SG styles, but both with pf very weak intensity and the first was without significance  $p = 0.18$ . In Close-Distance efficiency, there were very strong and significant positive correlations, respectively, with the styles SG ( $r_s = 0.934$ ;  $p < 0.01$ ) and GS ( $r_s = 0.877$ ;  $p < 0.01$ ), and a weak correlation with the SUS style efficiency. Thus, the efficiency level between the styles (specific skills) and distances is, in descending order: CD – SG; LD – SUS; CD – GS; SD – SUS. From these results, it is established that the fighters opted for specific styles and skills in accordance with the perceived distance for attack effectiveness. However, the choice of the appropriate distance by the fighters in order to perform effective attacks was also considered/was also taken into consideration. Therefore, it can be seen that the decision made by the fighters is the result of individual–context interaction.

**Table 3.** Spearman’s correlation coefficients obtained between distance and style efficiencies

|                                  | Submission Grappler Efficiency |      | Stand-Up Striker Efficiency |      | Ground Striker Efficiency |      |
|----------------------------------|--------------------------------|------|-----------------------------|------|---------------------------|------|
|                                  | $r_s$                          | $P$  | $r_s$                       | $p$  | $r_s$                     | $P$  |
|                                  | (n=340)                        |      |                             |      |                           |      |
| <b>Distances Efficiency</b>      | $r_s$                          | $P$  | $r_s$                       | $p$  | $r_s$                     | $P$  |
| <b>Long Distance Efficiency</b>  | .161**                         | .003 | .898**                      | .000 | .202**                    | .000 |
| <b>Short Distance Efficiency</b> | .128*                          | .018 | .444**                      | .000 | .194**                    | .000 |
| <b>Close Distance Efficiency</b> | .934**                         | .000 | .252**                      | .000 | .877**                    | .000 |

– \*\* Significant correlations  $p < 0.01$ ; \* Significant correlations  $p < 0.05$ .

## Discussion

This study aimed to investigate the offensive efficiency in relation to the different combat styles and distances of the winners and losers who participated in the WUFC World Ultimate Full Contact Championships held in Portugal between 2008 and 2017.

In addition, it clarified the relationship between the efficiency of the different styles (specific skill) and distances.

Overall, the results revealed that the winners showed higher efficiency than the losers, with statistically significant difference in all Combat Styles, their specific offensive technical-tactical actions and Combat Distances.

The results show that the winning or losing effect clearly depends on the offensive efficiency. The higher efficiencies observed by the winners in all combat styles and distances mean greater stability, versatility and adaptability. Comparing, by total values (i.e., winners and losers), the different Distance Efficiencies with the different Style Efficiencies, it was observed that specific combat styles are more highly related with specific combat distances. That is to say, the fighters select specific actions according to the perceptual contextual variation (i.e., different distances), but the contextual variation is also a purposeful approach to carry out efficient attacks.

In general, the ratio between the effective offensive actions and the offensive actions made (Kalina, 2002; Kalina et al., 2004) showed that the winners had a significant advantage over the losers in the offensive technical-tactical action, that is, they attacked more and the attacks were more effective W ( $Av= 60.12$ , mean rank= 232, 44); L ( $Av= 25.58$ , mean rank= 108.56) and ( $U= 3920.00$  and  $p= 0.000$ ). Thus, it can be said that the winners are the most offensive and efficient athletes. Therefore, the offensive action proves to be a major and determining factor for being successful in combat and achieving the victory. These data are in line with previous studies conducted in judo (Boguszewski, 2014b; 2016). The results suggest that the fight winners were characterized by significant higher offensive activeness (W: 0.31; L: 0.17,  $p < 0.01$ ) and attack effectiveness (W: 0.22; L: 0.01,  $p < 0.01$ ), whereby the attack effectiveness of the winners was also higher (W: 0.34; L: 0.00,  $p < 0.01$ ). In the same vein, another study (Boguszewski & Boguszewska, 2006), showed that the winners attacked more often, and 21% of those attacks were effective, while the losers' attacks were only 2% effective, with a significant difference between them ( $p < 0.01$ ). In conclusion, the same authors (Boguszewski & Boguszewska, 2006), stated that offensive activity can be relevant in the both fighters' analysis and their efficiency is one of the fundamental and distinguishing winners' characteristics. The attack relevance was also mentioned in taekwon do, karate and boxing competitions, where the winning athletes attacked more (El Ashker, 2011; Koropanovski et al., 2008; Koropanovski & Jovanović, 2007; Wąsik et al., 2014). In fact, increasing the number of attacks and always putting the opponent on the defensive reduces his or her efficiency (Wąsik et al., 2014).

For each offensive combat style, the Submission Grappler was verified as the most efficient style of fighting, followed by the Ground Striker and Stand-Up Striker. The statistically significant difference on the winning and losing effect was in the same order. In accordance with the 170 matches analyzed, most fight outcomes were by submission 84 (49.4%) through chokes and joint locks. The Ground Striker was the second most efficient style, whereby its specific skill, the Ground and Pound, is usually associated with the fight's outcomes by technical knockout (TKO) or knockout (KO), this being a characteristic action of the winners. According to a previous study on MMA (Adam et al., 2015), the Ground and Pound action was decisive for ultimate success, while in ground fighting, the athlete who limited his/her techniques to blows (Striking) and achieved the most dominant on the ground obtained a clear advantage in the tactical and technical offensive. However, it should be noted that the specific skills of SUS style (i.e., Kicks and Punches) showed more efficiency, these actions being those that produced the best points score and fight outcomes by decision or TKO/KO. Also, the most efficient specific skills in ground fighting (i.e., Submission Grappler and Ground Striker) were the Takedowns. These are the technical-tactical resources in stand-up fighting to take down the opponent and seek the end of the fight through locks and chokes or strike while fighting on the ground (i.e., Ground and Pound). In fact, the greater number and effectiveness of offensive actions in the stand-up fight influence the creation of tactical patterns during the fight, and a larger technical repertory increases the opportunity for attack (Adam et al, 2015; Segedi, Sertić, Franjić, Kustro, & Rozac, 2014). In accordance, all other skills also showed higher efficiency by the winners, namely the SUS Kicks and Punches were higher than Chokes, Knees and Joint Locks, respectively. But, in the significant difference of winning or losing effect, the Chokes had the highest significance, followed by the Kicks, Knees and Joint Locks. The Punches skills had a higher efficiency' than the Chokes skills; in fact, the overall striker styles' efficiency (SUS and GS) evidenced more efficiency than the Submission Grappler, which is responsible for the fight outcomes by decision and technical knockout/knockout. In fact, Striking had greater technical-tactical action effectiveness than Submission Grappling throughout combat, according to an MMA study, where striking appeared prominently (Adam et al, 2015).

The above conclusions determined that to be an efficient fighter, the competitor must be technically tactically versatile with multifaceted knowledge of how to fight both standing up and on the ground. Knowledge and the versatility are fundamental factors in performance – that is, knowing how to combine Full Contact with Grappling, and the hand techniques with feet techniques (Urquidez, 1981). The best MMA fighters and winners revealed high skills both in striking and grappling, with the increase in

efficiency being related to an increase in the frequency of techniques used' (Adam et al, 2015). Therefore, it becomes necessary to develop fundamental motor skills for greater performance in the combat dynamics of ground and stand-up fighting (Bocioaca, 2014). It is important to highlight the Chokes and Joint Locks techniques effectiveness; they are connected to the fight Outcome by submission (winners), with Chokes being the most efficient action in this submission method. According to WUFC world fight reports between 2008 and 2017 (WUFC, 2019b), the Rear-Necked Choke is the most common submission in fight Outcomes (17.1%), followed by the Armbar (10.0%), the Guillotine Shock (8.8%) and the Triangle Shock (5.3%), respectively.

In Stand-Up fighting, the highest efficiency was at the Kicking level, followed by the Punching and lastly the Kneeing. However, there was a greater frequency of Punching blows in Stand-Up Fighting than Kicking and Kneeing. The greater frequency of fist blows is in line with the studies conducted in Karate and in Taekwon-Do (Koropanovski et al., 2008; Wąsik & Ślęzak, 2004) where the Straight Punches were most used, followed by the Kicks. It can be said that, although the Kicking techniques are less frequent, they are more effective because, due to the risk of failure and vulnerability, they are usually performed with certainty. In fact, fighters often use fist techniques, such as Straight Punches (Jab and Cross), just to maintain a long distance and thus perform Kicking techniques more safely and accurately. However, Punching, which was revealed to have a higher significant difference in the winning or losing effect, is the most usual cause of TKO 33 (19.4%) and KO 18 (10.6%).

The fact that the winners showed higher efficiency in all Combat Distances reveals a great capacity of contextual adaptation by these athletes. It is in the Close Distance where the winners showed the most efficiency. In fact, the development of the fight at that distance is associated with a greater domain and control over the opponent, enabling greater effectiveness in the tactical-technical actions. The dominant ground position enabled a significant advantage to be gained in striking techniques using both hands (Adam et al, 2015).

By comparing the different styles with the different distances, higher significant correlations between specific Combat Styles efficiency and specific Combat Distances were confirmed. At Long Distance, the fighters opted mainly for technical-tactical actions with large amplitude (i.e., upper and lower members in full or almost complete extension at the point of impact with the target), such as kicks (i.e., Low Kick, Roundhouse Kick, Front Kick, Axe Kick, Side Kick, Hook Kick, Spinning Hook Kick, Spinning Back Kick) and straight punches (i.e., Jab, Cross, Spinning Back Fist). Otherwise, at Short Distance the fighters opted mainly for technical-tactical actions with less amplitude (i.e., upper or lower members flexing at the impact with the target),

such as short punches (i.e., Hook, Uppercut) and knees strikes. At Close Distance the fighters opted mainly for hand-to-hand fighting, where technical-tactical actions involve body control (Takedowns / Throws, Chokes, Joint Locks and Ground and Pound). These fight dynamics are in line with a study carried out in boxing, where the fighters strike (short punches or straight punches) in accordance with the distance perceived (opportunity) (Hristovski et al., 2006).

It should be noted that the lower efficiency between Stand-Up Strikers with Short Distance could be due to the fact that short punches are used less frequently than straight punches. This is because when the distances are shortened, many fighters instead of punching, choose grabbing, clinging or arm dragging as the way to control, immobilize or takedown the opponent. Similarly, in a boxing study (Kruszewski et al., 2016), the straight punches (i.e., Jabs) were used more, while hooks and the uppercuts (i.e., short punches) were significantly less frequently used. This could be in line with the concept that when the frequency increases so too does efficiency (Adam et al, 2015). Finally, it was noticeable that the contextual information (i.e., different distances) implies different combat dynamics, that is, combat styles appropriate to the respective distances. Accordingly, it can be remarked that the decision-making by fighters varies according to the context (individual–context interaction), meeting a dynamic-ecological behavioral perspective, where the action emerges spontaneously according to the perceived opportunities (i.e., affordances) (Fajen et al., 2008). In this perspective, the present results go against what was previously reported in a boxing study (Hristovski et al., 2006), which evidenced the efficiency of decision-making by performing the appropriate specific boxing actions, depending on the target–boxer distance variants. In addition, a Krav Maga study (Sánchez-García, Villaroya-Gil, & Elrío-López, 2015) that analyzed the tasks of manipulation, creating restrictions in a situational normality, it was found that the adaptability was only achieved by experts, since the decision-making and performance were affected by the challenging situation, where the experience level contributed to explaining the behavioral differences between the participants. In fact, the decision-making and the action emerged as a situational opportunity result, in this case the different distances. However, the different distances are also a consequence of the styles and the actions used by the fighters according to their own objectives (experiences and skills), making the attack more efficient. Therefore, the right technical-tactical actions (accurate, safe, economical, fast and unpredictable), at the right time (timing), are only possible through the memorized knowledge and skills developed through experience; this is the same as in tactical reasoning (Castelo et al., 1996; Lee, 1975; Pinto, 2015; Mahlo, 1997). It is noteworthy that all technical-tactical action in combat must comply with its structural and

functional assumptions, in order to avoid execution errors (presenting opportunity to the opponent) and meet the objectives effectively (Pinto, 2015). Thus, it is justified to develop training methods where analytical and integrated exercises coexist, based on technical-tactical repetitions (i.e., automation) and sparring (i.e., in a practice competition). This should be developed with a partner: a) selecting and repeating the more efficient skills (stand-up and ground fighting), focusing on offensive technical-tactical versatility and its constraints (e.g. combat styles, adaptation, balance, timing, opportunity, unpredictability and adaptability to different combat distances); b) sparring (integral or conditioned), applying the technical-tactical actions developed in the first method; or with the trainer: through Plastrons/Shields/Punch Mitts workout, which allows the trainer to make the fighter repeat the skills or create representative combat situations, stimulating cognitive and ecological dynamic processes (articulating different combat styles with different distances).

## **Conclusions**

The analysis of the offensive dynamic in Ultimate Full Contact related with the combat styles and distances provided very useful information for technical-tactical training processes. These data bring new information about the fighters tactical behavior in offensive efficiency.

Thus, this study concluded that: The winners were more efficient in all combat styles and distances, with statistically significant differences, so the effect of winning or losing considerably depends on the offensive efficiency; the higher efficiencies observed in the winners in all combat styles, their specific skills and distances, highlight greater stability, versatility, adaptability and opportunity seizing; the specific combat style efficiencies are more highly related with specific combat distance efficiencies, highlighting that the fighters select specific actions according to the perceptual contextual variation (different distances), however the distances are also a purposeful approach to attack with efficiency.

The higher offensive efficiency in styles depends, in decreasing order on Submission Grappler, Ground Striker and Stand-Up Striker; however, in their specific skills, the Punches and Kicks in Stand-Up Striker showed more efficiency than the Chokes and Joint Locks. Also, Takedowns, the specific skills of Ground Fighters related with the way to bring down the opponent to the ground and there, try to beat him or her through Submission Skills or Ground and Pound, were the most efficient specific skill. These further reinforce the importance of technical-tactical versatility in winning fights.

Highlight the fact that Offensive Efficiency is related with the adjusted between the appropriate combat distances (i.e., long range, short range, and close range) and

specific combat styles (i.e., Stand-Up Strikers, Ground Strikers and Submission Grapplers). The combat distance variation provides different spaces between the opponents, forcing different dynamics with high technical-tactical diversity (i.e., adaptability and opportunity seizing). As a result, the athletes decide to choose combat styles that are most favorable to the different contextual circumstances, taking into account their individual skills, the combat strategies planned and the Ultimate Full Contact particularities. Therefore, it becomes necessary to enhance cognitive and situational training processes through skills repetition and sparring. Therefore, it is necessary to enhance cognitive and situational training processes through skills repetition and sparring, which should be undertaken using analytical and integrated methods' to promote a perfect and representative technical-tactical structural and functional development (i.e., stability, versatility, adaptability and opportunity sense).

### **Highlights**

- The offensive efficiency related with styles, its skills, and distances is a combat dynamic that is both decisive and determinant in the fighter's performance.
- Specific combat styles and their skills are significantly related with specific combat distances for higher offensive efficiency.
- Stand-Up Fighters must develop defense strategies (e.g. evasive displacements, balance, sprawling, punching, kicking), keeping proper distance to avoid being taken to the ground, since the takedowns and ground fighting are shown to be very efficient.
- Technical-tactical stability, versatility, adaptability and opportunity seizing are determinant factors for higher offensive efficiency.
- Training processes based on the interaction of cognitive and dynamic ecologic models must be considerable to improve and develop the adjustable structural and functional technical-tactical actions.

### **Acknowledgments**

The authors would like to thank the WUFC World Ultimate Full Contact – Association for the support in this investigation.

## **Study 3**

### **Anticipated, Simultaneous and Posterior Counter-Attack Efficiency in Ultimate Full Contact**

#### **Abstract**

Background & Study Aim- Ultimate Full Contact is a hybrid combat sport, where the counter-attack technique takes on special importance. However, to the best of our knowledge, no study has analyzed the dynamics of anticipated, simultaneous and subsequent counter-attacks as a distinct technical-tactical efficiency for the fighters' performance. This study aimed to clarify the relevance of the tactical counter-attack efficiency related to its temporal responses. Materials and Methods- 170 fights were observed, integrating (n= 340) senior male athletes representing 38 countries, who participated in the WUFC World Championships; all technical-tactical counter-attacks made and effective, by winners and losers, were registered and analyzed through Spearman's bivariate correlation, the Kalina method for counteroffensive efficiency and Mann-Whitney U. Results- The results indicate that winners had significant advantage in all counteroffensive skills regarding their temporal responses, with the number of counter-attacks made and their efficiency both decreasing: Anticipated, Simultaneous and Posterior. The counter-attack made by the losers was in opposite order, but its efficiency was in the same order with significant difference, except at Posterior Counter-Attack. The Anticipated Counter-Attack showed 100% efficiency. Conclusions- This study showed that winners counter-attacked more and more effectively, therefore showed greater efficiency. Anticipated counter-attack and simultaneous counter-attack proved to be the temporal responses that most contributed to winning a fight. It is important to develop prior defensive actions, which create a favorable fight distance and body stance for these counter-attacks, as well as developing related capacities (e.g. perception, anticipation, opportunity, timing, strategies).

**Keywords:** combat sports; ground fighting; skills; technical-tactical; counteroffensive; time; anticipation; opportunity; stand-up; dynamics

## **Introduction**

Ultimate Full Contact is a combat sport promoted by the World Ultimate Full Contact (WUFC) since 1988 (Pinto, 2015). It is characterized by an intermittent and complex structure concerning the physiological resources and technical-tactical dynamics (i.e., offensive, counteroffensive and defensive actions) (Pinto, 2015). The technical-tactical factor is evidenced as a determining dynamic in Ultimate Full Contact competitions (Pinto, 2015). Based on this dynamic, the counter-attack has been shown to be a very effective strategy in all fighting arts (Romashov, 2019). Therefore, the counter-attack is considered a safe and assertive strategy in combat (i.e., waiting for the opponent to prepare him/herself to attack, or attacks to counter-attack him/her), creating great psychological pressure on the opponent (Hao, 2019; Wallace, 1982). In fact, the counter-attack consists of a defense-based action that seeks the opportunity to counter-attack, switching the fighter's behavior from passive to active, which gives them greater control over the fight (Hao, 2019). Previous researches in judo (Boguszewski, 2014, 2016; Boguszewski & Boguszewska, 2006) have shown that the counteroffensive dynamics (i.e., switching from defensive to offensive action) in combat is one of the characteristics of those winners with significantly higher effectiveness.

The execution of the counter-attack is directly influenced by the fighter's decision-making, and by taking advantage of the opportunities created (Hao, 2019). Thus, tactical ability can play an important role during combat, which allows an advantage to be obtained quickly, and to use the opponent's possible mistakes to one's advantage (Boguszewski & Boguszewska, 2006). Furthermore, intentional simulations create a latent response in the opponent, and the real intentional offensive must take place at that moment, instead of waiting for mistakes or for the opponent's attack (Malkov & Romashov, 2018). In addition, the ability to continually manage the psychological refractory periods created by anticipations (i.e., response latency) is one of the essential characteristics for success in Ultimate Full Contact competitions (Pinto, 2015).

In fact, playing in the counter-offensive becomes more rigorous when the sport develops under very broad rules, using complex and extremely powerful techniques, as in Ultimate Full Contact and other similar modalities (e.g. Pankration, Free-Fight or Mixed Martial Arts (MMA) (Pinto, 2015). Effectively, in Ultimate Full Contact, an infinity of technical-tactical resources are allowed, ranging from the striker to the grappler, with stand-up fighting and / or on-ground fighting, aiming to effect blows or submit the opponent, in a context of high tenacity, variability, transience and unpredictability (Pinto, 2015).

In this context, the high complexity of Ultimate Full Contact influences tactical behavior, specifically in quality, quick-thinking and in the adequate understanding of

the situation according to competitive requirements (Castelo et al., 1996; Pinto, 2015). Variability (i.e., pace of change) requires high perceptual demands, while transience (i.e., complexity of change) requires a capacity for efficient intervention through anticipation (Castelo et al., 1996). Thus, the response must be executed in time, according to the opponent's attack situation (Hao, 2019).

In Ultimate Full Contact, there are numerous standardized specific counter-attack strategies, namely between two right-handed fighters (i.e., orthodox stance), right cross counterpunch to a right low kick; counter-attack double-leg takedown to punch strikes; right spinning back or hook kick counter-attack to a right cross or left roundhouse kick; right cross counterpunch to left jab; left hook counterpunch to a right cross (Federação Portuguesa de Full Contact [2018], 2018). However, the counter-attack is directly related to the immediately previous defensive action (e.g. blocking, parrying, dodging, displacement, escape or jamming/intercepting) which creates a favorable fight distance and body stance for a prompt counter-attack (Federação Portuguesa de Full Contact, 2018; Hao, 2019; Romashov, 2019; Wallace, 1982). Thus, the correct application of counterattack tactics requires that fighters have excellent attack and defense techniques, which have been demonstrated by the winners (El Ashker, 2011; Hao, 2019). However, even if the fighter opts for a more defensive style, the attack/counter-attack is essential for success, since sooner or later one of the fighters will have to use offensive techniques to win the fight (Urquidez, 1981). Corroborating this evidence, previous studies have reported that the offensive and / or counteroffensive was a decisive combat dynamic to defeat the opponent (Boguszewski, 2011; Boguszewski & Boguszewska, 2006; David & López, 2014; Romashov, 2019). Thus, any block (i.e., defensive action) must be followed by a counter-attack (i.e., offensive action); if the fighter constantly blocks the opponent's actions without counter-attack, he will eventually be hit (Forbes & Kolliopoulos, 2004; Urquidez, 1981). In addition, the effectiveness of the counter-attack requires maintaining the proper distance and must occur after escaping the opponent's attack, hitting them while they are still attacking and unbalanced as a result of the attack failure, or hitting them before they start' starts the offensive action (Hao, 2019; Romashov, 2019; Urquidez, 1981; Wallace, 1982).

Therefore, the visual reaction time can be considered a critical capacity for performance and is essential for the performance of the best fighters (Asia & Warkar, 2013; Borysiuk, 2008; Fontani, Lodi, Felici, Migliorini, & Corradeschi, 2006; Mori, Ohtani, & Imanaka, 2002; Rosalie & Muller, 2013; Vences Brito & Silva, 2011;). Thus, the ability to anticipate is also essential for performance, given its relationship to time-sensitive interceptive actions (Roi & Bianchedi, 2008). In fact, anticipation is one of the fundamental tactical behaviours throughout the phases of perception and situational

analysis, representing the ability to discern and predict the needs and consequences in the competitive situation (Hucko, 1981; Korcek, 1981). Consequently, anticipation depends on making eminently cognitive decisions related to the counter-attack (Sagnol & Bisciotti, 1997). An accurate anticipation of the opponent's intentions is vital for a quick offensive or defensive movement and is more correlated with the recognition of emotions of dynamic action (Shih & Lin, 2016). Thus, anticipation is characterized as a process based on mental construction, pre-perception, pre-decision and pre-action, introducing the future into the present (Parlebas, 1981). It is a process in which tactical experiences are fundamental, prioritizing the predictive activity of the development actions (Bayer, 1974; Meinel, 1984). In this approach, the anticipated response depends on the ability and quick perception to understand the situational variability of the fights (Malkov & Romashov, 2018). The counter-attack of the expert fighters is based on an ideomotor response model (action programming) as opposed to an inexperienced counter-attack (Malkov & Romashov, 2018). Excessive self-control in critical situations can delay the responses and benefit the opponent (Malkov & Romashov, 2018). In this reasoning, in order to be successful in the anticipated spontaneous responses, the fighter must develop the qualities and skills according to the different types of temporal responses quite common in the fights (Malkov & Romashov, 2018).

In fact, the way in which counter-attacks are developed highlights the differences in the athletes' performance, which emphasizes the importance of tactical consciousness throughout the fight (Hao, 2019). However, previous studies only highlight the counter-attack efficiency, based on the ratio between effective and realized techniques (Bocioaca, 2014; Boguszewski, 2011, 2014, 2016; Boguszewski & Boguszewska, 2006), not taking into account the relevance of the tactical counter-attack efficiency in relation to the temporal responses (i.e., anticipation, simultaneous or posterior) to the opponent's attacks or intentions. In addition, the previous counter-attack studies were developed in combat sports, like judo, boxing, tae kwon do, wrestling or karate, with limited rules when compared to Ultimate Full Contact. Thus, a gap in the literature is evident since to the best of our knowledge, no study has analyzed the dynamics of anticipated, simultaneous and subsequent counter-attacks as a distinct technical-tactical efficiency for the performance of the Ultimate Full Contact Fighter.

Therefore, this study aims, identifies and characterizes, according to the winning and losing athletes, the counter-attack dynamics (i.e., Anticipated, Simultaneous and Posterior) according to the opponents' attacks, with the purpose of identifying the most efficient and distinct counter-attack forms of the winners. This knowledge will effectively contribute to improving representative training methods and consequently improve the athletes' technical-tactical performance (Bocioaca, 2014; David & López,

2014; El Ashker, 2011; Fajen, Rilley, & Turvey, 2008; González & Miarka, 2013; Hristovski, Davids, Araújo, & Button, 2006; Kalina et al., 2004; Miarka, Julio, Vecchio, Calmet, & Franchini, 2010).

## **Material and Methods**

### **Subjects**

Three hundred and forty, senior male athletes (master class - minimum level of national champions or high rank in different Combat Sports or Martial Arts, aged  $\geq 18$ , among all weight divisions) representing 38 countries participated in the study, including 170 (50.0%) winners and 170 (50.0%) losers, who had participated in the WUFC Ultimate Full Contact World Championship, held annually in Portugal between 2008 and 2017. These athletes were chosen, because they are top athletes in the world, according to the WUFC world rankings (World Ultimate Full Contact [WUFC], 2018). The fights observed consisted of a total time of 43120 ( $253.65 \pm 203.65$ ), where 33 (19.4%) were completed in the round's total time of 1x 10' (600 ") and resulted in a decision. However, 137 (80.6%) of the matches ended before the final time: 84 (49.4%) by submission; 18 (10.6%) by knockout (KO); 33 (19.4%) by technical knockout (TKO); and 2 (1.2%) by doctor stoppage (DS).

### **Instruments and procedures**

The methodology was based on the Kalina method for analysis of struggle dynamics, with regard to the counteroffensive efficiency (Kalina, 2002; Kalina et al., 2004), but grouping the techniques by their tactical behavior, according to the different types of temporal responses (Malkov & Romashov, 2018). Thus, the data collection was done by observing the video footage of the 170 fights (provided by WUFC World Ultimate Full Contact). The observation consisted of the necessary pauses and replays, in order to correctly obtain all the quantitative and qualitative information regarding the technical-tactical counter-attack actions performed as well as the effective ones, depending on the winning and losing athletes. The data were registered in observation grids, specifically created for this purpose in Microsoft's Excel Office 365 program, with all variables. The data collection (i.e., counter-attack technical-tactical actions) were guided by the following variables: Counter-attacks – Anticipated Made, Simultaneous Made, Posterior Made, Made Total; Counter-attacks – Anticipated Effective, Simultaneous Effective, Posterior Effective, Effective Total; Counter-attacks – Anticipated Efficiency, Simultaneous Efficiency, Posterior Efficiency and Total Efficiency. The study was performed in accordance with the Declaration of Helsinki and

maintains the anonymity of the players according to European data protection law. The ethical approval for this study was obtained from the local ethics committee.

### **Statistical analysis**

The normality of the data was verified by the Kolmogorov–Smirnov test, confirming that there was no normal distribution. Thus, the analysis was performed using the non-parametric statistical tests, particularly the Spearman’s bivariate correlation and the Mann–Whitney U tests. Therefore, after an initial step, where the descriptive statistical values of each variable under study were obtained, we used the inferential statistics, using the first test mentioned above. The relation intensity was verified, whether with positive or negative direction, and the significance between the variables related to the different technical-tactical counter-attack actions performed as well as the effective ones, comparing the values between the winning and the losing athletes. To interpret the relation intensity, the Cohen & Holliday’s correlation magnitude scale was used, referred to as follows: Very weak correlation and without significance ( $r \leq 0.19$ ); Weak correlation ( $0.2 \leq r \leq 0.39$ ); Moderate correlation ( $0.4 \leq r \leq 0.69$ ); Strong correlation ( $0.7 \leq r \leq 0.89$ ); Very strong correlation ( $0.9 \leq r \leq 1$ ) (Cohen & Holliday, 1982); In the correlations, the significance of  $p < 0.01$  and  $p < 0.05$  were determined.

From the study, the counter-attack efficiency variables were also calculated by the respective technical-tactical dynamics (i.e., Anticipated, Simultaneous and Posterior Counter-Attacks) through the ratio between the number of effective actions and the number of made actions (Kalina, 2002; Kalina et al., 2004). After this procedure, the effect of winning or losing under the different efficiency variables was calculated using the Mann–Whitney U method, considering the significance of  $p < 0.05$ .

### **Results**

From the 170 matches observed (Table 1), the winners made a total of 274 ( $1.61 \pm 1.88$ ) counter-attacks, with 242 effectives ( $1.42 \pm 1.59$ ), while the losers made 138 ( $0.81 \pm 1.13$ ) counter-attacks with 86 effectives ( $0.51 \pm 0.85$ ). At the outset, it can be stated that the winning athletes chose to play more counter-attacks than the losers.

Table 1 shows the descriptive data for the different forms of counter-attacking and it can be observed that the winners made a greater number of counter-attacks, and effectives, except for the Posterior Counter-Attacks made.

The Anticipated Counter-Attack form is 100% effective in both winning and losing athletes. It is also this form of counter-attack that is the most used by the winners, followed by the Simultaneous Counter-Attack and lastly the Posterior Counter-Attack.

Curiously, in the loser athletes, the opposite is true: that is, they usually use the Posterior Counter-Attack, followed by the Simultaneous and finally the Anticipated.

**Table 1.** Descriptive data of technical tactical actions of counter-attacks made, and effective, by winners and losers

| <b>Counter-attacks</b>        | <b>Winners (n=170)</b> |            |               |           |            | <b>Losers (n=170)</b> |            |               |           |            |
|-------------------------------|------------------------|------------|---------------|-----------|------------|-----------------------|------------|---------------|-----------|------------|
|                               | <i>Min-Max</i>         | <i>Sum</i> | <i>Av ±SD</i> | <i>Me</i> | <i>IQR</i> | <i>Min-Max</i>        | <i>Sum</i> | <i>Av ±SD</i> | <i>Me</i> | <i>IQR</i> |
| <b>Anticipated Made</b>       | 0-6                    | 134        | 0.79<br>±1.07 | 0.00      | 1.00       | 0-3                   | 29         | 0.17<br>±0.45 | 0.00      | 0.00       |
| <b>Simultaneous Made</b>      | 0-4                    | 84         | 0.49<br>±0.80 | 0.00      | 1.00       | 0-2                   | 49         | 0.29<br>±0.54 | 0.00      | 0.00       |
| <b>Posterior Made</b>         | 0-6                    | 56         | 0.33<br>±0.71 | 0.00      | 1.00       | 0-4                   | 60         | 0.35<br>±0.72 | 0.00      | 1.00       |
| <b>Made Total</b>             | 0-13                   | 274        | 1.61<br>±1.88 | 1.00      | 2.00       | 0-6                   | 138        | 0.81<br>±1.13 | 0.00      | 1.00       |
| <b>Anticipated Effective</b>  | 0-6                    | 134        | 0.79<br>±1.07 | 0.00      | 1.00       | 0-3                   | 29         | 0.17<br>±0.45 | 0.00      | 0.00       |
| <b>Simultaneous Effective</b> | 0-3                    | 72         | 0.42<br>±0.68 | 0.00      | 1.00       | 0-2                   | 33         | 0.19<br>±0.45 | 0.00      | 0.00       |
| <b>Posterior Effective</b>    | 0-3                    | 36         | 0.21<br>±0.49 | 0.00      | 0.00       | 0-2                   | 24         | 0.14<br>±0.38 | 0.00      | 0.00       |
| <b>Effective Total</b>        | 0-9                    | 242        | 1.42<br>±1.59 | 1.00      | 2.00       | 0-5                   | 86         | 0.51<br>±0.85 | 0.00      | 1.00       |

Table 2 shows the values resulting from the analysis of the correlation between the variables of the technical and tactical counter-attack actions, both made and the effective ones, comparing the values between the winners and the losers.

**Table 2.** Spearman correlation coefficients obtained between counter-attacks made and effective

| Counter-attacks          | Anticipated Effective |                 |                |                 | Simultaneous Effective |                 |                |                 | Posterior Effective |                 |                |                 |
|--------------------------|-----------------------|-----------------|----------------|-----------------|------------------------|-----------------|----------------|-----------------|---------------------|-----------------|----------------|-----------------|
|                          | Winners (n=170)       |                 | Losers (n=170) |                 | Winners (n=170)        |                 | Losers (n=170) |                 | Winners (n=170)     |                 | Losers (n=170) |                 |
|                          | $r_s$                 | <i>p</i> -value | $r_s$          | <i>p</i> -value | $r_s$                  | <i>p</i> -value | $r_s$          | <i>p</i> -value | $r_s$               | <i>p</i> -value | $r_s$          | <i>p</i> -value |
| <b>Anticipated Made</b>  | 1.000**               | .               | 1.000**        | .               |                        |                 |                |                 |                     |                 |                |                 |
| <b>Simultaneous Made</b> |                       |                 |                |                 | 0.941**                | 0.000           | 0.801**        | 0.000           |                     |                 |                |                 |
| <b>Posterior Made</b>    |                       |                 |                |                 |                        |                 |                |                 | 0.805**             | 0.000           | 0.672**        | 0.000           |
| <b>Made Total</b>        | 0.785**               | 0.000           | 0.523**        | 0.000           | 0.572**                | 0.000           | 0.529**        | 0.000           | 0.365**             | 0.000           | 0.471**        | 0.000           |

\*\* Significant correlations  $p < 0.01$ ; \* Significant correlations  $p < 0.05$ .

Through the intensities of the relation between the variables, a complete proximity can be confirmed with the Anticipated Counter-Attacks made and effective ones, both by the winners and losers, verifiable by the values of  $r_s = 1.00$ . This correlation, considered as very strong, expresses the high efficiency of the early counter-attacks in combat. With regard to the Simultaneous Counter-Attack, the proximity between counter-attacks made and the effective ones is no longer so close; however, it is also a very strong relation in the winners, with  $r_s = 941$  and strong in the losers, with  $r_s = 801$ , both with both positive and significant direction, considering the significance of  $p = 0.01$ . However, the Posterior Counter-Attack shows lower, but strong relation intensities in the winners, with the value of  $r_s = 805$ , and moderate relation intensities in the losers, with the value of  $r_s = 672$ , both also significant at the  $p < 0.01$  level.

### Counter-attack efficiency

Through the ratio between the counter-attacks made and the effective counter-attacks obtained, the efficiency variables by the grouping of athletes (winners and losers) show higher averages of efficiency by the winners in all variables, as shown (Table 3). With regard to the overall counter-attack efficiency, the averages confirmed the superiority of the winner athletes. However, in the case of non-normal distribution data, it became more reliable to observe the Mean Ranks values (Table 4), but nonetheless, they were also found to be higher in the winners in all efficiency variables.

**Table 3.** Descriptive data of technical tactical actions of counter-attacks efficiency

| <b>Counter-attacks</b>         | <b>Winners (n=170)</b> |                           |               |            | <b>Losers (n=170)</b> |                           |               |            |
|--------------------------------|------------------------|---------------------------|---------------|------------|-----------------------|---------------------------|---------------|------------|
|                                | <i>Average</i>         | <i>Standard Deviation</i> | <i>Median</i> | <i>IQR</i> | <i>Average</i>        | <i>Standard Deviation</i> | <i>Median</i> | <i>IQR</i> |
| <b>Anticipated Efficiency</b>  | 49.41                  | 50.14                     | 0.00          | 100.00     | 14.71                 | 35.52                     | 0.00          | 0.00       |
| <b>Simultaneous Efficiency</b> | 20.06                  | 34.23                     | 0.00          | 33.33      | 11.86                 | 29.13                     | 0.00          | 0.00       |
| <b>Posterior Efficiency</b>    | 17.55                  | 37.78                     | 0.00          | 0.00       | 10.74                 | 29.45                     | 0.00          | 0.00       |
| <b>Total Efficiency</b>        | 64.92                  | 45.75                     | 100.00        | 100.00     | 29.41                 | 42.88                     | 0.00          | 75.00      |

In Table 4 it can be stated that the differences between the winners and the losers were significant in all variables ( $p < 0.05$ ), except for the Posterior Counter-Attacks Efficiency, with  $p = 0.14$ . Also, it is perceptible which variable makes the biggest difference between the winning and the losing athletes, observing the lowest U value: this value coincides with the Anticipated Counter-Attacks Efficiency variable, with  $U = 9435.00$  and  $p = 0.00$ , followed by Simultaneous Counter-Attacks Efficiency and finally Posterior Counter-Attack Efficiency. Considering the Counter-Attacks Efficiency Totality, the significant advantage of the winners in this combat dynamics is noticeable, which is confirmed by the higher rank's values and by the low value of  $U = 8893.50$ , with  $p = 0.00$ .

**Table 4.** Mann–Whitney test effectuated between winners and losers, in the different variables of counter-attacks efficiency

| <b>Counter-attacks</b>         | <b>Winners (n=170)</b> |                     | <b>Losers (n=170)</b> |                     | <i>Mann–Whitney U</i> | <i>p-value</i> |
|--------------------------------|------------------------|---------------------|-----------------------|---------------------|-----------------------|----------------|
|                                | <i>Mean Rank</i>       | <i>Sum of Ranks</i> | <i>Mean Rank</i>      | <i>Sum of Ranks</i> |                       |                |
| <b>Anticipated Efficiency</b>  | 200.00                 | 34000.00            | 141.00                | 23970.00            | 9435.00               | 0.000          |
| <b>Simultaneous Efficiency</b> | 182.84                 | 31083.50            | 158.16                | 26886.50            | 12351.50              | 0.002          |
| <b>Posterior Efficiency</b>    | 175.50                 | 29835.00            | 165.50                | 28135.00            | 13600.00              | 0.136          |
| <b>Total Efficiency</b>        | 203.19                 | 34541.50            | 137.81                | 23428.50            | 8893.50               | 0.000          |

## Discussion

This study aimed to investigate the counteroffensive effectiveness according to the different types of temporal responses to opponents' attacks, between winners and losers among top fighters who have participated at the annual WUFC World Ultimate Full Contact Championship held in Portugal between 2008 and 2017. Overall, the results reveal that the winners stood out in all Counter-Attack Technical-Tactical Effectiveness Dynamics. The Anticipated Counter-Attack was the most made and efficient action by the winners, followed by the Simultaneous Counter-Attack and lastly by the Posterior Counter-Attack.

Curiously, the counter-attacks made by the losers were in the opposite sequence to that of the winners, favoring the Posterior Counter-Attack followed by the Simultaneous and finally by the Anticipated. However, the effectiveness order of the different counter-attack forms by winners and losers was the same. With regard to the effect of the winning and losing efficiency differences, a significant difference was observed between the Anticipated Counter-Attacks Efficiency groups and between the Simultaneous Counter-Attack groups, but not in the Posterior Counter-Attacks Efficiency groups. In terms of the Total Counter-Attack Efficiency, a significant difference was also observed between the winners' and the losers' groups. These results, in the general counter-attack effectiveness perspective, are in accordance with the previous studies that also showed the higher counter-attack efficiency by the winners (Boguszewski, 2014, 2016; Boguszewski & Boguszewska, 2006; Vidranski, Maškarin, & Jukić, 2015). Nevertheless, the present study adds in relation to what was previously reported, the efficiency of the counter-attack related to the time of its execution in

response to the opponent's attacks. In fact, the different types of temporal responses, quite common in the fights, interfere with the skills related to mental control mechanisms (Malkov & Romashov, 2018).

In general, the counter-attack proved to be a very efficient combat dynamic, regardless of the way it is performed (i.e., different types of temporal responses regarding the opponent's attack), given that there are notably high values of correlation between the techniques performed and the effective ones in the three ways. Previous studies (Bocioaca, 2014; Boguszewski, 2011, 2014, 2016; Boguszewski & Boguszewska, 2006; Hao, 2019; Kalina et al., 2004; Miarka et al., 2010; Romashov, 2019; Vidranski et al., 2015) have also shown the counter-attack as the technically most effective dynamic, its execution causing a connection of counter speeds between the fighters, and quite often leads to knockdowns and knockouts of the opponent (Romashov, 2019). However, in the present study, it has been added to the previous acknowledgement that the anticipated counter-attack stands out with a positive and very strong correlation of  $r_s = 1.00$ , which means 100% effectiveness. In fact, anticipation proves to be an essential capacity in terms of performance, which goes against what has been previously described in some studies (Asia & Warkar, 2013; Ayu, Suwarganda, & Mohd Nor, 2015; Borysiuk, 2008; Mori et al., 2002; Roi & Bianchedi, 2008; Shih & Lin, 2016; Vences Brito & Silva, 2011) that identify it as a quality of expert fighters. Although less efficient than the anticipated counter-attack, the counter-attack that is made simultaneously to the opponent's attack also proved to be very efficient and was used more often by the winners, while the Posterior Counter-Attack, was used more often by the losing fighters than the winners ( $0.35 \pm 0.72$  vs  $0.33 \pm 0.71$ ), although with less effectiveness ( $r_s = 0.672$  vs  $0.805$ ;  $p < 0.01$ ). Perhaps due to the lower quality of execution, as evidenced in tae kwon do analyses (Ayu et al., 2015), where the winners showed 2187 total attempts, of which 9% attacks and 7% defense were successful; non-winners had 2352 total attempts, achieving 5% success for attack and 2% for defense. Even though non-winners attempted more than winners, the winners had higher successfulness in attacking and defensive tactics (Ayu et al., 2015).

The counter-attack performance requires the capacity to seek the opportunity with excellent previous defense followed by spontaneous attacks/counter-attacks, keeping an appropriate distance and supple dodging and moving through a tactical consciousness (Romashov, 2019). This defence-attack cycle was evidenced by expert fighters' actions that resembled counter-attack dynamics before a stimulus, while the beginner fighters' actions resembled defensive patterns without counter-attack (Ottoboni, Russo, Tessari, & Francis, 2015). Therefore, from the present investigation, where the anticipated and simultaneous counter-attacks are the tactically most

performed and efficient, it can be inferred that, from the defense actions normally prior to the different counter-attack time execution – the jamming, the dodging or move/displacements (i.e., those more associated with the Anticipation and Simultaneous Counter-Attacks) – are more efficient action types than the blocks or the parries (i.e., those more associated with the Posterior Counter-Attack) (Forbes & Kolliopoulos, 2004; FPFC, 2018; Hao, 2019; Romashov, 2019; Romashov, Malkov, & Zvezdova, 2018; Urquidez, 1981; Wallace, 1982). In fact, by prioritizing the defensive actions such as jamming and dodging or moving a counter-attack can take place at the moment that the opponent is preparing to start the attack (action timing) or simultaneously to the opponent's attack, causing their attack to be lost (Romashov et al., 2018; Urquidez, 1981; Wallace, 1982). Also, in a study based on top-ranking professional boxing match replays, it was considered that lateral movements (i.e., dodging or lateral displacements) with counter-attacks, as a technical-tactical action, is highly recommended in combat (Romashov et al., 2018). While, blocking requires impacts and occupation of the members who carry them out, so these actions must be carried out as a last resort and, when they are carried out, too much time should not be spent just blocking, but a counter-attack should be made immediately (Forbes & Kolliopoulos, 2004; Urquidez, 1981; Wallace, 1982).

This information emphasizes the following qualities and abilities in the execution of a counterattack: seizing the opportunity; anticipation; fast perception; precise interpretation and decision-making; exact timing; right distance and balance; combat strategy; opponent strategies study; efficiency in tactical-technical defense and attack/counter-attack automation and adaptation; efficiency in psychological refractory periods management (i.e., response latency); mental control; and the fighter's behavioral patterns (i.e., intended and spontaneous actions) (Asia & Warkar, 2013; Ayu et al., 2015; Bocioaca, 2014; Boguszewski, 2011; Borysiuk, 2008; Castelo et al., 1996; El Ashker, 2011; Forbes & Kolliopoulos, 2004; FPFC, 2018; Hao, 2019; Malkov & Romashov, 2018; Miarka et al., 2010; Mori et al., 2002; Ottoboni et al., 2015; Pinto, 2015; Romashov, 2019; Romashov et al., 2018; Rosalie & Muller, 2013; Shih & Lin, 2016; Urquidez, 1981; Vidranski et al., 2015; Wallace, 1982).

Finally, compared the differences were compared between the counterattack's efficiencies according to the different times of their responses, once the previous studies had analyzed the counter-attack efficiency in terms of the generally effective techniques related to the made techniques (Bocioaca, 2014; Boguszewski, 2011, 2014, 2016; Boguszewski & Boguszewska, 2006; Kalina et al., 2004). With regard to this, it was verified that the winning or losing effect difference was significant under the Anticipated and Simultaneous Counter-Attack efficiency, except for the Posterior

Counter-Attack efficiency. The biggest difference between the winning or losing effect was registered in the Anticipated Counter-Attack, followed by the Simultaneous and finally the Posterior Counter-Attacks. In this specific analysis, it was found that anticipation is also the most efficient time for a counter-attack. This information reinforces the importance of the capacity for anticipation in sports (Asia & Warkar, 2013; Ayu et al., 2015; Borysiuk, 2008; Castelo et al., 1996; Malkov & Romashov, 2018; Mori et al., 2002; Ottoboni et al., 2015; Pinto, 2015; Romashov, 2019; Rosalie & Muller, 2013; Shih & Lin, 2016; Urquidez, 1981). With regard to the generality of counter-attack efficiency, this proved to be a significant combat dynamic in the winning or losing effect (Mean Ranks: 203.19 vs 137.81;  $U = 8893.50$ ;  $p = 0.00$ ) with the percentages (0.65 vs 0.29). Effectively, the counter-attack is the winning athletes' predominant dynamic, which is also supported by the following studies: where the counter-attack efficiency was very high in the winners (0.66 vs losers 0.13) (Boguszewski & Boguszewska, 2006); where the counter-attack effectiveness index registered 0.43 for gold medalists and 0.00 for silver medalists (Boguszewski, 2014); where the winners demonstrated significantly higher counter-attack effectiveness than the losers (0.67 vs 0.00  $p < 0.001$ ) (Boguszewski, 2016).

From these results, it is recommended to develop technical-tactical training processes that focus the development of counter-attack dynamics. Highly effective counter-attacks should assist as orientation to coaches and athletes for high-level competition (Boguszewski, 2011). However, the training process should place emphasis on the anticipated counter-attack form (i.e., time action). The capacities, qualities and abilities for the development of anticipation must be integrated and representative of the competitive context (i.e., opportunity sense, fast perception / interpretation, precise decision-making, exact timing, strategies, adjustable distance, balance, automated and adaptive defenses and counter-attack actions). It is important to develop defense actions that precede the counter-attacks (i.e., blocking, parrying, dodging, displacement, escape and jamming/interception). However, it is important to prioritize dodging, displacement and jamming, which are more related with anticipated and simultaneous counter-attacks, because these are the base-defenses with which to counter-attack the opponent before they start the attack, or to counter-attack the opponent while they are still attacking and unbalanced as a result of having lost the attack in the void (Hao, 2019; Romashov, 2019; Urquidez, 1981; Wallace, 1982). It should be noted that, in order to have success in the counter-attack, it is necessary to master both defense and attack actions (Hao, 2019).

## **Conclusion**

The counter-attack technical-tactical dynamics and its effectiveness are included in the factors that influence the performance in combat sports. In fact, in the analysis carried out on the technical-tactical effectiveness of the counter-attack, it was the winning athletes who stood out in all the counter-attack dynamics related to the different time of responses.

The anticipated counter-attack was the preponderant action by the winners, followed by the simultaneous counter-attack and lastly by the posterior, while the losing athletes revealed the reverse order of preponderance. However, with regard to the counter-attack's effectiveness, the same order was verified by both winners and losers, with the anticipated being the most effective action, followed by the simultaneous and finally the posterior. It should be noted, at the posterior counter-attack level, that the losing athletes perform this action more often than the winners, albeit less effectively. This may be due to the lower quality of execution.

In general, the counter-attack proved to be a very efficient combat dynamic, regardless of the way it is executed, as there were high values of correlation between the techniques made and the effective ones in the three counter-attack forms. The anticipated counter-attack stands out with a positive correlation of  $r_s = 1.00$ , which means 100% effectiveness. The ability to anticipate proves to be an essential factor in the performance of Ultimate Full Contact fighters.

Therefore, it is inferred that from the immediately previous defensive actions to the counter-attack executions: the jamming, dodging and slipping (i.e., more associated with anticipated or simultaneous counter-attack) will be more efficient types of action than blocking or parrying (more associated with posterior counter-attack).

The effect of winning or losing is significant under the variables of anticipated and simultaneous counter-attack efficiency, except for the efficiency of the posterior counter-attack. The biggest difference between the effect of winning or losing was registered on the anticipated counter-attack level, followed by the simultaneous and finally the posterior. The counterattack efficiency, in general, proved to be a significant combat dynamic in the winning or losing effect.

Thus, the results of this study can be useful for coaches in order to enhance the performance of their fighters. Therefore, it is important to organize technical-tactical training processes to develop the counter-attacks and their base-defenses, focusing on the anticipation responses and their related qualities, skills and capacities (e.g. seizing opportunity, quick perception/interpretation, timing, distance, balance, certain and correct techniques). The objective is to train discerning athletes, capable of perceiving and anticipating the opponent's intentions, developing a high decision-making capacity

to neutralize the opponent's attacks and increase the efficiency and effectiveness of the attack/counter-attack (Pinto, 2015).

### **Highlights**

- The counteroffensive efficiency related with its temporal responses is a decisive and determinant combat dynamic in the fighter's performance.
- In general, the counter-attack, regardless of the temporal form executed (anticipated, simultaneous, posterior), is a very efficient combat dynamic.
- The anticipated and simultaneous counter-attacks are the most efficient forms.
- Technical-tactical training processes with counter-attack dynamics and its base-defenses must be considerable to improve the performance of the Ultimate Full Contact fighters.

### **Acknowledgments**

The authors would like to thank the WUFC World Ultimate Full Contact – Association for the support in this investigation.



## **Study 4 - Ultimate Full Contact: defensive efficiency and ground fighting control, interrelating the different technical-tactical skills performed in the WUFC world championships**

### **Abstract**

Defensive skills and ground fighting control are essential in combat sports; even when attacking, defensive and fighting control skills must always be present. Therefore, their analysis becomes relevant to obtain useful recommendations for the efficient planning of combat strategies in Ultimate Full Contact, where studies on this dynamic are limited. 170 fight DVDs were observed between senior male fighters (master class; n = 340) from 38 countries; all defensive and ground fighting control skills (winners and losers) were recorded and analyzed using the Mann Whitney U test and Kalina's method for the combat dynamics analysis (only defensive efficiency index). Results: Winners were more efficient in evading (dodging and displacements), escaping, sprawling, and parrying, while the losers were more efficient in blocking. The winners used mount control, side control, and back control most successfully, while the losers used closed guard, immobilization (e.g., pull down, over hook), sweeps, and half guard more successfully. The greater difference between winning or losing was verified through the evading, sprawling, mount, side control, and back control. Conclusions: Winners were more active and efficient in defensive skills and ground fighting control. The winners' defenses were useful to avoid impact, to perform counterattacks, to avoid being taken down, and ending the fight on the ground. Winners' ground fighting control was predominantly associated with dominant positions, which were more stable and favorable for striking or making opponents submit, while the losers were forced to maintain their defensive skills.

**Keywords:** combat sports, fighting dynamics, defence, strategy, dominant stances and actions

## **Introduction**

Since 1988, the World Ultimate Full Contact WUFC Championships have taken place every year in Portugal. This is a highly competitive event that brings together top-ranked fighters from several countries (Federação Portuguesa de Full Contact [FPFC] 2018a; Pinto 2015; WUFC 2018). Ultimate Full Contact is a hybrid full contact sport of extreme complexity requiring intermittent technical-tactical and physiological resources, the articulation of single and combination actions in stand-up and ground fighting, and the creation of an environment of high variability, tenacity, and unpredictability (Federação Portuguesa de Full Contact, 2018a, 2018b; Pinto, 2015; WUFC, 2018).

Fighters must have high and varied technical-tactical repertoires with regard to offensive/counter-offensive and defensive dynamics (Pinto, 2016). However, attack is only part of the strategy necessary for success. In fact, for the most efficient fighters, refined defensive skills play an important role (Forbes & Kolliopoulos, 2004). This means that, even when an offensive action is taken, defense against a possible counterattack must be intentional and assured. Thus, the defensive skills have to be associated with offensive actions, and this is a technical-tactical aspect that characterizes the performance of winning fighters (Adam & Sterkowicz-Przybycień, 2018; Ashker, 2011). Previous studies have shown that winners are more efficient in offensive and defensive dynamics (Adam & Sterkowicz-Przybycień, 2018; Ashker, 2011; Boguszewski, 2006, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; Kassim, Suwarganda, & Nor, 2015; Miarka et al., 2016; Slimani et al., 2017).

However, it is clear that, due to the demands of Ultimate Full Contact, where you can fight standing-up (in vertical posture) and/or on the ground (in horizontal posture), with a high variability in attack skills (i.e., kicks, knees, punches, elbows, takedowns, chokes, joint locks, and ground and pound), defensive efficiency and the ground control become a dynamic of special complexity and importance.

In view of the abovementioned, to have an effective defensive strategy means to develop high and varied defensive resources in accordance with the features of Ultimate Full Contact. Therefore, the present study identifies and characterizes defensive and control dynamics of winners and losers, contrasting the different defensive technical-tactical actions (e.g., dodge, block, parry, and sprawl) with the opponents' attacks. In addition, the dynamics of ground fighting control are assessed and compared with the different technical-tactical actions (e.g., mount, closed guard, and rear mount). Information on grappling actions is required for fighters and coaches to improve their training plans, since these skills are associated with different technical-tactical movements and different levels of efficiency (Adam, Pujszo, Kuźmicki, & Szymański,

2015; Del Vecchio, Hirata, & Franchini, 2011; Miarka et al., 2016; Miarka, Brito, & Amtmann, 2017). Thus, the aim of the present study is to identify the level of defensive efficiency and the most efficient and distinct technical-tactical actions within the defensive repertoire and control of ground fighting dynamics between winners and losers in male's competition.

## **Material and Methods**

### **Subjects**

Three hundred and forty senior male fighters were observed (master class – minimum level of national champions or high grade in their styles, aged  $\geq 18$  and from all weight divisions), representing 38 countries, and included 170 (50.0%) winners and 170 (50.0%) losers who had participated in the WUFC Ultimate Full Contact World Championships, held every year in Portugal between 2008 and 2017. These fighters were chosen because they are world class, according to the WUFC world rankings (WUFC, 2018). The total time of the fights observed was 43,120" ( $253.65 \pm 203.65$ ), of which 33 (19.4%) ended by decision, that is, the regular combat time was completed (1 round x 10'); 137 (80.6%) finished before the regular combat time: 84 (49.4%) by submission, 33 (19.4%) by technical knockout (TKO), 18 (10.6%) by knockout (KO), and 2 (1.2%) by doctor stoppage (DS).

### **Instruments and procedures**

Detailed data observation grids with quantitative and qualitative variables were used, built using Microsoft Excel Office 365 software. The information was obtained through recorded fights provided by the WUFC. Recordings of the fights were observed in detail, with the necessary pauses and repetitions, and all technical-tactical actions of the attacks and respective successful defensive actions and ground control actions of the winners (W) and losers (L) were registered. The main technical-tactical actions for defense and ground control were recorded according to the technical regulations of the WUFC. They are characterized as follows: defensive skills (i.e., parrying, blocking, evading [dodging and displacements], sprawling, and escaping); and ground control skills (i.e., closed guard, half guard, mount, side control, north south control, back control, back side control, reversals or sweeps, and immobilizations). After this procedure, the data were coded and exported to the IBM SPSS Statistics 24 software, where the respective statistical analyses were performed. The study was performed in accordance with the Declaration of Helsinki and maintains the anonymity of the

players according to European data protection law. The ethical approval for this study was obtained from the local ethics committee.

### **Statistical analysis**

The Kolmogorov–Smirnov test was used to verify the normality of the sample and it revealed no normal data distribution. Thus, the Mann Whitney U statistical test was used to identify the difference in the efficiency of winning or losing according to the effect of all efficiency variables in analysis and considering the significance of  $p < 0.05$ . The efficiency variables were calculated according to Kalina's method for defensive dynamic efficiency (Kalina 2002) through the ratio of successful defensive actions (excluding counterattack) to the opponent's attacks, excluding those that were followed by counterattack.

### **Results**

In the first observation, it was found that 2,533 attacks were carried out by the winners, while the losers carried out only 1,657. These actions resulted in a total of 1,203 successful defenses by the winners and 1,155 by the losers. Table 1 presents the descriptive data on the efficiency of the different defensive resources used by the fighters. Based on the values found, the winners were more efficient in all defensive resources, with an emphasis on evading efficiency ( $37.49 \pm 30.59$ ) followed by escaping efficiency ( $9.07 \pm 16.559$ ), amongst the other variables. However, the results indicate that the losers had an advantage in blocking efficiency ( $L = 2.08$  e  $W = 0.00$ ) and the winners at the level of evading efficiency ( $W = 36.36$  e  $L = 16.67$ ). At the end of Table 1, the results show that the winners showed greater defensive efficiency ( $W = 65.40 \pm 30.01$ ;  $71.43$  and  $L = 36.20 \pm 21.65$ ;  $37.50$ ).

**Table 1.** Descriptive data of defensive technical tactical actions and general defensive efficiency

| <b>Defense Successful</b>   | <b>Winners (n=170)</b> |                           |               |            | <b>Losers (n=170)</b> |                           |               |            |
|-----------------------------|------------------------|---------------------------|---------------|------------|-----------------------|---------------------------|---------------|------------|
|                             | <i>Average</i>         | <i>Standard Deviation</i> | <i>Median</i> | <i>IQR</i> | <i>Average</i>        | <i>Standard Deviation</i> | <i>Median</i> | <i>IQR</i> |
| <b>Parrying Efficiency</b>  | 5.49                   | 10.63                     | 0.00          | 7.69       | 2.97                  | 5.99                      | 0.00          | 4.01       |
| <b>Blocking Efficiency</b>  | 8.46                   | 15.19                     | 0.00          | 12.50      | 8.18                  | 11.62                     | 2.08          | 12.64      |
| <b>Evading Efficiency</b>   | 37.49                  | 30.59                     | 36.36         | 57.14      | 18.04                 | 15.85                     | 16.67         | 28.75      |
| <b>Sprawling Efficiency</b> | 5.18                   | 16.31                     | 0.00          | 0.00       | 1.41                  | 4.74                      | 0.00          | 0.00       |
| <b>Escaping Efficiency</b>  | 9.07                   | 16.55                     | 0.00          | 12.50      | 5.60                  | 9.27                      | 0.00          | 10.09      |
| <b>Defensive Efficiency</b> | 65.40                  | 30.01                     | 71.43         | 39.61      | 36.20                 | 21.65                     | 37.50         | 30.36      |

IQR = Interquartile range

In Table 2, higher levels of efficiency were observed for the winners in all defensive resources, except for blocking efficiency. The variables parrying efficiency, with  $p = 0.23$ ; blocking efficiency, with  $p = 0.22$ ; and escaping efficiency, with  $p = 0.33$ , did not show statistically significant differences between winners and losers. With regard to the variables evading efficiency and sprawling efficiency, these revealed statistically significant differences ( $p < 0.05$ ). Thus, the highest difference in defensive efficiency between winners and losers was found in evading efficiency (i.e., body dodging or displacement and avoiding impacts), with  $U = 9028.50$  and  $p = 0.00$ , followed by sprawling efficiency (i.e., to avoid being takedown), with  $U = 12895.50$  and  $p = 0.01$ . The losers registered their greatest efficiency in blocking efficiency (Mean Rank 176.54) but without significant difference in relation to the winners  $p > 0.05$ . In terms of defensive efficiency in general, it was observed that the winners were significantly more efficient in the defensive dynamic, as shown by the following values: Mean Rank ( $W = 219.54$ ;  $L = 121.46$ ); Sum Rank ( $W = 37322.50$ ;  $L = 20647.50$ ); and  $U = 6112.50$ , with  $p = 0.00$ .

**Table 2.** Mann Whitney test effectuated between winners and losers, in the different variables of defensive efficiency

| <b>Defensive Skills</b>     | <b>Winners (n=170)</b> |                     | <b>Losers (n=170)</b> |                     | <i>U Mann-Whitney</i> | <i>p-value</i> |
|-----------------------------|------------------------|---------------------|-----------------------|---------------------|-----------------------|----------------|
|                             | <i>Mean Rank</i>       | <i>Sum of Ranks</i> | <i>Mean Rank</i>      | <i>Sum of Ranks</i> |                       |                |
| <b>Parring Efficiency</b>   | 175.72                 | 29872.00            | 165.28                | 28098.00            | 13563.00              | 0.233          |
| <b>Blocking Efficiency</b>  | 164.46                 | 27957.50            | 176.54                | 30012.50            | 13422.50              | 0.216          |
| <b>Evading Efficiency</b>   | 202.39                 | 34406.50            | 138.61                | 23563.50            | 9028.50               | 0.000          |
| <b>Sprawling Efficiency</b> | 179.64                 | 30539.50            | 161.36                | 27430.50            | 12895.50              | 0.009          |
| <b>Escaping Efficiency</b>  | 175.02                 | 29753.00            | 165.98                | 28217.00            | 13682.00              | 0.331          |
| <b>Defensive Efficiency</b> | 219.54                 | 37322.50            | 121.46                | 20647.50            | 6112.50               | 0.000          |

Significance  $p < 0.05$

Table 3 presents the descriptive data for the technical-tactical dynamics of ground fighting control. Through the frequencies or sums and averages of the actions performed, it was observed that the winners were superior at the level of the following actions: side control; mount; back control; back side control; and north south, while the losers were superior in the following actions: closed guard; immobilization; reversals or sweeps; and half guard.

At the level of general ground fighting control, the winners successfully performed 578 ( $3.40 \pm 3.15$ ) technical-tactical actions, while the losers successfully performed 462 ( $2.72 \pm 3.52$ ). The data showed that the winners were more active in this dynamic, and the actions in which they were predominant reflected a more stable fighting strategy, with dominant and favorable positions for striking or making their opponents submit. The technical-tactical characteristics of ground fighting control revealed by the losers mainly reflected the defensive style.

**Table 3.** Descriptive data of successful ground fighting control skills

| Ground Control              | Winners (n=170) |     |            |      |      | Losers (n=170) |     |            |      |      |
|-----------------------------|-----------------|-----|------------|------|------|----------------|-----|------------|------|------|
|                             | Min-Max         | Sum | Av ±SD     | Me   | IQR  | Min-Max        | Sum | Av ±SD     | Me   | IQR  |
| <b>Closed Guard</b>         | 0-7             | 87  | 0.51 ±1.01 | 0.00 | 1.00 | 0-8            | 156 | 0.92 ±1.43 | 0.00 | 1.00 |
| <b>Half Guard</b>           | 0-2             | 11  | 0.06 ±0.27 | 0.00 | 0.00 | 0-3            | 29  | 0.17 ±0.48 | 0.00 | 0.00 |
| <b>Mount</b>                | 0-4             | 103 | 0.61 ±0.91 | 0.00 | 1.00 | 0-1            | 12  | 0.07 ±0.26 | 0.00 | 0.00 |
| <b>Side Control</b>         | 0-3             | 123 | 0.72 ±0.97 | 0.00 | 1.00 | 0-3            | 26  | 0.15 ±0.45 | 0.00 | 0.00 |
| <b>North South</b>          | 0-2             | 11  | 0.06 ±0.27 | 0.00 | 0.00 | 0-2            | 5   | 0.03 ±0.20 | 0.00 | 0.00 |
| <b>Back Control</b>         | 0-5             | 82  | 0.48 ±0.79 | 0.00 | 1.00 | 0-3            | 16  | 0.09 ±0.35 | 0.00 | 0.00 |
| <b>Back Side Control</b>    | 0-2             | 24  | 0.14 ±0.41 | 0.00 | 0.00 | 0-4            | 9   | 0.05 ±0.38 | 0.00 | 0.00 |
| <b>Reversals or Sweeps</b>  | 0-4             | 52  | 0.31 ±0.67 | 0.00 | 0.00 | 0-5            | 73  | 0.43 ±0.85 | 0.00 | 1.00 |
| <b>Immobilization</b>       | 0-4             | 85  | 0.50 ±0.89 | 0.00 | 1.00 | 0-7            | 136 | 0.80 ±1.27 | 0.00 | 1.00 |
| <b>Ground Control Total</b> | 0-18            | 578 | 3.40 ±3.15 | 3.00 | 4.00 | 0-15           | 462 | 2.72 ±3.52 | 1.00 | 3.00 |

**Min-Max** = Minimum-Maximum; **Av** = Average; **SD** = Standard Deviation; **Me** = Median; **IQR** = Interquartile Range

Table 4 shows the values of the ground fighting control skills and the differences in their effect on winning or losing. The biggest differences were observed in the variables mount ( $U = 9479.00$ ;  $p = 0.00$ ); side control ( $U = 9577.00$ ;  $p = 0.00$ ); and back control ( $U = 10463.50$ ;  $p = 0.00$ ). Significant differences were observed in all variables except for the skills north south ( $U = 13943.00$ ;  $p = 0.104$ ) and reversals ( $U = 13539.50$ ;  $p = 0.183$ ). Examining ground fighting control in general, the winners' superiority in successful technical-tactical control skills was verified. There was a statistically significant difference in this combat dynamic ( $U = 11207.50$ ;  $p = 0.00$ ). This means that higher ground control efficiency was an important fighting dynamic for winners.

**Table 4.** Mann Whitney test effectuated between winners and losers, in the different variables of successful ground fighting control skills

|                             | Winners (n=170) |              | Losers (n=170) |              | U Mann-Whitney | p-value |
|-----------------------------|-----------------|--------------|----------------|--------------|----------------|---------|
|                             | Mean Rank       | Sum of Ranks | Mean Rank      | Sum of Ranks |                |         |
| <b>Close Guard</b>          | 158.30          | 26911.50     | 182.70         | 31058.50     | 12376.50       | 0.007   |
| <b>Half Guard</b>           | 163.92          | 27866.00     | 177.08         | 30104.00     | 13331.00       | 0.016   |
| <b>Mount</b>                | 199.74          | 33956.00     | 141.26         | 24014.00     | 9479.00        | 0.000   |
| <b>Side Control</b>         | 199.16          | 33858.00     | 141.84         | 24112.00     | 9577.00        | 0.000   |
| <b>North South</b>          | 173.48          | 29492.00     | 167.52         | 28478.00     | 13943.00       | 0.104   |
| <b>Back Control</b>         | 193.95          | 32971.50     | 147.05         | 24998.50     | 10463.50       | 0.000   |
| <b>Back Side Control</b>    | 178.36          | 30321.00     | 162.64         | 27649.00     | 13114.00       | 0.001   |
| <b>Reversals or Sweeps</b>  | 165.14          | 28074.50     | 175.86         | 29895.50     | 13539.50       | 0.183   |
| <b>Immobilization</b>       | 159.71          | 27151.50     | 181.29         | 30818.50     | 12616.50       | 0.019   |
| <b>Ground Control Total</b> | 189.57          | 32227.50     | 151.43         | 25742.50     | 11207.50       | 0.000   |

Significance  $p < 0.05$

## Discussion

The present study aimed to analyze defensive efficiency in relation to the fighters' attacks by comparing the efficiency of defensive skills between senior male winners and losers who participated in the WUFC Championships held in Portugal between 2008 and 2017. Ground fighting control performance was also assessed. The results revealed that in general the winners were more efficient in defense than the losers. In particular, the winners were more efficient than the losers in evading (dodging and displacements), escaping, sprawling, and parrying skills, while the losers were more efficient than the winners in blocking skills. With regard to ground fighting control, the winners used more successful dominant positions (i.e., mount control, side control, and back control), while the losers were forced to take more defensive actions (i.e., closed guard, immobilization, reversals/sweeps, and half guard). The greater difference in the effect on winning or losing was verified at the level of defensive efficiency (evading and sprawling) and at the level of ground fighting control (mount control, side control, and back control).

The winners attacked and defended more than the losers. These findings are in line with previous studies which have shown that offensive activity and defensive skills' effectiveness were higher amongst winners (Adam & Sterkowicz-Przybycień, 2018; Ashker, 2011; Boguszewski, 2006, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; Kassim et al., 2015; Slimani et al., 2017). Winners showed significantly higher defensive effectiveness in one study (winners 1.00, losers 0.57;  $p < 0.001$ ; Boguszewski, 2016). Another study involved the analysis of 70 fights records from the 2008, 2010, and 2012 World Championships, where the partial averages consistently presented significantly higher values of defensive efficiency compared with other fighting dynamics: for the female winners and losers 0.983 and 0.764, respectively, and for the male winners and losers 0.984 and 0.819, respectively. There was a significant difference between groups ( $p < 0.05$ ; Boguszewski, 2014a). The finalists in the European Championships showed a very high efficiency of defensive actions (0.92), where the champions showed higher defensive efficiency than the vice-champions (0.98 and 0.82, respectively;  $p < 0.01$ ) (Boguszewski & Boguszewska, 2006). Kassim et al. (2015) also found that the winners had a higher percentage of defensive success compared with losers: W = 151 (7%) and L = 56 (2%).

In terms of the efficiency of defensive skills, the winners were more efficient in evading (i.e., dodging and displacements), sprawling, escaping, and parrying than the losers, while the losers were more efficient than the winners in blocking. The data showed that the winners opt for body dodging or displacement (i.e., more complex actions) instead of blocks, and that they resorted more to sprawling and escaping to avoid being taken down and defeated by submission skills. In fact, evading strategies can be identified as the most suitable for success in defensive actions, since they avoid impact and make the hands or legs available for counterattacking (Davis, Benson, Waldock, & Connorton, 2016; Davis, Wittekind, & Beneke, 2013; Korobeynikov et al., 2020; Lee & Modrić, 1975; Malkov & Kalashikov, 2015; Malkov & Zvesdova, 2018; Romashov, 2019; Urquidez, 1981). The greater efficiency in blocking by the losers may be due to the fact that it is a simpler and more natural defensive method when one is in a position of technical inferiority.

Significant differences between winners and losers were found in evading and sprawling skills. These were more diverse and complex in terms of defensive efficiency, which aligns with a previous study in which complex defensive ability was determined to be factor in fighting success (Cular & Krstulovic, 2011). In addition, in a study carried out with boxers, the winners had more advanced defensive skills and technical efficiency (Ashker, 2011).

The lower values displayed in sprawling amongst the losers meant that they were taken down more, which is in keeping with previous research showing that higher successful takedowns were a characteristic of winners (Kirk, Hurst, & Atkins, 2015; Miarka et al., 2017), and that a significant number of outcomes were the result of ground fighting (James, Kelly, & Beckman, 2013, Miarka et al., 2016). In this field it is important to highlight the higher efficiency that the winners of the present study demonstrated in the escaping and sprawling to avoid the fight that the opponent intended, since ground fighting has proved to be an effective strategy. From the abovementioned, it is known that the effect of winning or losing depends more on efficiency in evading and sprawling.

However, defensive skills revealed, in general, great efficiency, making technical-tactical defense actions a very significant dynamic in combat, as previously described (Adam & Sterkowicz-Przybycień, 2018; Ashker, 2011; Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; Kassim et al., 2015). In ground fighting control, the winners were superior to the losers in the side control, mount control, back control, back side control, and north south control while the losers stood out in closed guard, immobilization, reversals/sweeps, and half guard control. The winners were more active in this dynamic, and the characteristics of the actions in which they showed to be predominant were associated with a ground fighting strategy that allowed for more stable and favorable positions to strike or make the opponents submit while fighting on the ground. In fact, the fighting control has been revealed as efficient strategy to dominate the opponents and sequentially attack them (Branco et al., 2013; Marcon, Franchini, Jardim, & Neto, 2010). In contrast, the losers showed a ground fighting strategy that was mainly defensive (i.e., closed guard, immobilization [e.g., pull down, over hook], and sweeps). This is in line with a previous study where the top fighters had shown many advantages in ground striking, such as their capacity for postural movements and control through dominant positions, limiting the opponents' movements on the floor and striking them (i.e., ground and pound; (Crossley, 2015; Del Vecchio et al., 2011). In the latter study, the data from the ground fighting control showed that the winners performed significantly more offensive ground striking (0.86;  $p < 0.05$ ), offensive grappling (0.77;  $p < 0.05$ ), and defensive grappling (0.66;  $p < 0.05$ ) in a position of dominant control, while the losers were forced to enhance their defensive actions to avoid being hit, which was evidenced by the highest defensive percentage (0.63;  $p < 0.05$ ). Finally, in addition to the dominant position allowing significant striking advantage (Adam et al., 2015), many submission techniques were attempted from a dominant top position, which were significantly reduced without a dominant position (Adam et al. 2015; Crossley, 2015; Del Vecchio et al., 2011). The

control actions on the fighting ground (i.e., mount control, side control, and back control) were the skills that made the greater difference in terms of winning or losing. In fact, these were dominant ground positions that showed higher control capacity over the opponents, increasing the opportunity to win by T/KO through strikes (e.g., ground and pound) or by submission through chokes or joint locks. This in accordance with a study that identified the fights outcomes by T(KO) and submission with higher values for striking and grappling actions during the ground fight (Miarka et al., 2016).

## **Conclusions**

The winners were more active and efficient in their use of defensive resources in general and in ground fighting control, which suggests that these skills are technical-tactical dynamics that enhance performance in Ultimate Full Contact. The defensive skills evading (i.e., dodging and displacements), escaping, sprawling, and parrying were the more efficient dynamics of the winners, while blocking was used more efficiently by the losers. Thus, the winners could use more suitable defensive actions (e.g., evading), avoiding impact and allowing them to keep their hands or legs free to counterattack, while the defensive actions of the losers (i.e., blocking) were easier to execute when in situations of technical inferiority. In addition, the winners showed the ability (i.e., sprawling and escaping) to avoid being taken down and having to submit. In ground fighting control, the winners used dominant positions more successfully (i.e., mount control, side control, and back control), while the losers were forced to use more defensive actions (i.e., closed guard, immobilization, reversals/sweeps, and half guard). The winners' ground control was characterized by a more stable fighting strategy, with favorable positions to strike or make opponents submit, while the losers showed a ground fighting strategy that was mainly defensive. The largest difference between the effect of winning or losing was in defensive efficiency and in ground fighting control. This was verified significantly in evading and sprawling defensive skills and in mount control, side control, and back control.

The results of the present study could be extremely valuable to coaches, because they indicate the skills and technical-tactical dynamics that are most important for victory. They could therefore be used to create training exercises to improve fighting performance.

## **Practical Suggestions**

The following are suggestions to improve fighters' performance:

- Develop defensive skills based on dodges and displacements (i.e., evading) that reduce the absorption of impacts and create more favorable conditions for counterattacking;
- Develop defensive skills (i.e., sprawling and escaping) to avoid being taken down and submitted while ground fighting;
- Develop skills to take dominant and stable positions while fighting on the ground, creating more favorable conditions to attack or to make the opponent submit

### **Conflicts of Interest**

There were no conflicts of interest associated with this manuscript, financial or otherwise.

### **Funding**

This work is supported by national funding through the Portuguese Foundation for Science and Technology, I.P., under project UID04045/2020.

### **Acknowledgments**

The authors would like to thank the WUFC World Ultimate Full Contact – Association for the support in this investigation.

## **Study 5 - Ultimate Full Contact: fight outcomes characterization concerning their methods, occurrence times and technical-tactical developments**

### **Abstract**

Fight analysis produces relevant technical–tactical information. However, this knowledge is limited in hybrid full-contact combat sports. Therefore, this study aimed to characterize the results of the fights' outcomes through the winners at the World Ultimate Full Contact (WUFC) Championships between 2008 and 2017. Methods: 170 combats between senior male fighters (master class) from 38 countries were observed; all fight outcome methods, their occurrence times, inherent skills and their development forms were analyzed through frequencies, percentages, crosstabs and chi-square test, considering a Fisher's exact value of  $p < 0.05$ . The fight outcome methods were, in decreasing order, as follows: submission; decision and technical knockout (TKO); knockout (KO); and doctor stoppage. Only 19.4% fights completed the regular time 10 min (600 s), and 68.8% fight outcomes occurred in the first 5 min (300 s). Chokes were more used than joint locks, primarily developed in single actions. Head punches and kicks were the skills most responsible for KO, developed more in combinations and counter-attacks, while TKO was always through combination attacks and mostly by ground and pound. Ground fighting is most effective. In stand-up fighting, combination attacks and counter-attack are most effective. It is important to increase the technical–tactical capacities and adjustable decision-making to perform the regular fight time.

**Keywords:** combat sports; styles; skills; stand-up and ground fighting; submission; technical; knockout; KO; attack combinations; single attack; counter-attack

## **Introduction**

Ultimate Full Contact, promoted by the World Ultimate Full Contact (WUFC), is a combat art based on the technical–tactical actions and principles of martial arts/combat sports (i.e., pankration, taekwondo, Muay Thai, boxing, sambo, jiu-jitsu, wrestling, etc.) (Federação Portuguesa de Full Contact [FPFC], 2018a; Pinto, 2015). Thus, Ultimate Full Contact is characterized by being a hybrid combat sport with a very complex structure, developed in stand-up and/or ground fighting, and allowing striking and submission grappling skills (Federação Portuguesa de Full Contact, 2018a, 2018b; Pinto, 2015). The WUFC Championships have been taking place in Portugal since 1988, where many top fighters participate annually (Federação Portuguesa de Full Contact, 2018a; Pinto, 2015; WUFC, 2018).

This is a competition with great technical–tactical dynamics (i.e., offensive, counteroffensive and defensive actions) developed under constant and full physical contact of intermittent intensity throughout the combat (Federação Portuguesa de Full Contact, 2018b; Pinto, 2015). In fact, fights are developed under a context of high variability, tenacity and unpredictability, where the winner can be found by different methods (e.g., decision, submission, knockout (KO) or technical knockout (TKO) (Federação Portuguesa de Full Contact, 2018b; Pinto, 2015). These methods are common to pankration, free fight, shooto and mixed martial arts (MMA), which resulted from high technical variability (i.e., punches; kicks; knees; elbow strikes; and submission grappling actions like grabs, twists, takedowns, chokes and locks) (Kirk, Hurst, & Atkins, 2015).

Consequently, some authors (Miarka et al., 2016) consider that the skills inherent to the different fight outcomes can be associated with contextualized practices; that is, when the fight outcomes are by T(KO) and submission, the fighters present higher values of striking and grappling actions during the ground fight (Miarka et al., 2016), while in the fight outcomes by decision (i.e., split or unanimous), the fighters have higher values of striking actions during stand-up fighting (Miarka et al., 2016). In addition, the techniques (i.e., skills) with which the fighters end the fight (e.g., punches, kicks, chokes) characterize and categorize their styles (Buse, 2006). Furthermore, the frequency of victories for specific actions reflects the level of versatility of their training (Hackett & Storey, 2017). In fact, the technical–tactical actions performed through the fight are related to the type of outcome of the fight (Antonietto et al., 2019; James, Robertson, Haff, Beckman, & Kelly, 2017; Maszczyk et al., 2018; Miarka, Vecchio, Camey, & Amtmann, 2016).

Therefore, some studies have characterized the percentages of fight outcomes in different modalities, by gender (i.e., male and female) (Chaabene et al., 2014; Miarka et

al., 2016), fighters' classes (i.e., amateurs and professionals) (Dal Bello, Brito, Amtmann, & Miarka, 2019; Del Vecchio, Hirata, & Franchini, 2011; Hackett & Storey, 2017; James et al., 2017; Miarka et al., 2016) and skills (Antonietto et al., 2019; James et al., 2017; Miarka, Vecchio, et al., 2016). As a result, some factors have been identified for the different fight outcomes, e.g., specific fighting methods, physical conditioning, age, weighting, timing between fights, timing into the fight, fighting importance and technical efficiency (Chaabene et al., 2014; Hutchison, Lawrence, Cusimano, & Schweizer, 2014; James et al., 2017; Segedi, Sertic, Franjic, Kustro, & Rozac, 2014). In addition, through MMA studies, it is known that one-fifth of all wins by KO resulted from head punches in the first minute at the beginning of the round (Bledsoe, Hsu, Grabowski, Brill, & Li, 2006; Hutchison, Cusimano, Lawrence, & Singh, 2013), and in judo, a significant number of matches end before the expiry of the normal fight time (Segedi et al., 2014). Other previous studies (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2017; Kalina, 2002; Kalina et al., 2004; Koropanovski, Dopsaj, & Jovanović, 2008; Koropanovski & Jovanović, 2007; Slimani et al., 2017; Wąsik, Pieter, & Borysiuk, 2014) have provided some relevant information for this investigation but do not relate the results to the type of fight outcomes. For example, in studies (El Ashker, 2017; Slimani et al., 2017), related to the development of skills in boxing, it was determined that using boxing combinations is a characteristic of winners, highlighting the importance of punching more in combinations than alone to be more effective (El Ashker, 2017). This was in line with a review study that highlighted triple-punch combinations and counter-punch combinations as conditions for winning in novice and elite boxing competitions (Slimani et al., 2017). Moreover, it is known that attack/counter-attack in several combat sports has been shown to be a determining factor in winning fights due to its greater effectiveness, calculated through the ratio between attack/counter-attacks and effective attacks/counter-attacks (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2017; Kalina, 2002; Kalina et al., 2004; Koropanovski et al., 2008; Koropanovski & Jovanović, 2007; Wąsik et al., 2014).

Beyond this referred knowledge about the relationship that exists between the fight outcome methods/techniques and styles, little is known about the fight outcome methods and their inherent skills concerning their times of occurrence and forms of development, and, thus, more research is needed. In addition, little is known in general about the fight outcomes in Ultimate Full Contact, and the results can be of extreme importance in terms of some relevant recommendations for coaches and fighters. Therefore, the main aim of the present study was to characterize the fight outcomes in Ultimate Full Contact, which can certainly be extrapolated to other, similar modalities

(i.e., hybrid full contact combat sports). An aim of this study was to increase knowledge of tactical behavior, thus analyzing not only the percentages of the fight outcome methods (i.e., decision, submission, knockout KO, technical knockout TKO, and doctor stoppage (DS)) and the inherent technical–tactical skills (e.g., armbar, choke, head punch, high kick, ground and pound), but also how they were developed (i.e., single attack, combination attack, or counter-attack) and their times of occurrence in the fights. The following hypotheses were considered: most of fights end by decision; the fights' outcomes by medical decision are high, due to serious injuries or impediments to continue the fight; the fights that end before the regular time (i.e., KO, TKO, or submission) take place before the first 5 minutes of the fight; the fights that end by submission are mostly a sequence of choke skills; the fights that end by KO are mostly a sequence of punch skills; the fights that end by TKO are mostly a sequence of ground strike skills; the fights that end by KO are mostly a sequence of counterattack skills; the fights that end by submission are mostly a sequence of single submission skills; and the fights that end by TKO are mostly a sequence of combination strike skills.

## **Materials and Methods**

The present research is related to a case study regarding the WUFC World Ultimate Full Contact Championships. For this study, 170 recorded fights developed under professional rules between 340 senior male fighters, carried out between 2008 and 2017, were analyzed. All variables were analyzed statistically in order to accurately conclude the purposes of the study.

The variables in question were characterized according to WUFC rules and terminology: winners (W) and losers (L); fight times; fight outcome methods (i.e., decision, submission, knockout KO, technical knockout TKO and doctor stoppage DS); technical–tactical skills inherent to the fight outcome methods (i.e., armbar, rear-naked choke, guillotine choke, triangle choke, leg lock, arm-triangle choke, heel hook, keylock, spinning back kick, high kick, head punch, knee strike, ground and pound and stand-up strikes); and how the technical–tactical skills are developed (i.e., single attack, attack combinations and counter-attack).

It should be noted that other technical–tactical actions also allowed in the WUFC regulations were not reported in this study, as they were not found in the sample. In addition, the inclusion criteria predetermined the above appointed five combat outcome methods, so the results by disqualification and related to combats that finished in a “draw” or “no contest” were not included.

In relation to the meaning of the fight outcome methods, according to the WUFC rules (Federação Portuguesa de Full Contact, 2018b): winning by decision means that the

fight reaches the end of the regular time, and the result is decided by the judges through points scored; winning by submission happens when one of the fighters taps out due to a submission technique applied by the opponent; winning by knockout (KO) happens when one of the fighters is unable to continue the fight due to having suffered a strike; winning by technical knockout (TKO) occurs when the referee considers that one of the fighters demonstrates technical inferiority due to their opponent's strikes.

## **Subjects**

Three hundred and forty senior male athletes (master class—minimum level of national champions or high rank in different combat sports or martial arts, aged  $\geq 18$ , among all weight divisions) representing 38 countries, 170 (50.0%) winners (W) and 170 (50.0%) losers (L) were included. These fighters participated in the WUFC World Ultimate Full Contact Championships held in Portugal each year between 2008 and 2017. The fighters were selected because they are top-ranked in the WUFC according to the inclusion criteria (WUFC, 2018).

## **Instruments and Procedures**

As instruments of data collection, detailed observation grids with all quantitative and qualitative variables were used, built in the Microsoft Excel Office 365 software (Microsoft, Washington, United States). The information was obtained through the recorded fights, provided by the WUFC World Ultimate Full Contact.

All combat recordings were observed in detail, with the necessary pauses and repeats, and fight outcome methods, technical–tactical actions, their development and occurrence times in the fights were all recorded. Then, the data were encoded and exported to the IBM SPSS Statistics 24 software (IBM, New York, United States), where the respective statistical analyses were performed. The study was performed in accordance with the Declaration of Helsinki and maintains the anonymity of the players according to European data protection law. The ethical approval for this study was obtained from the local ethics committee.

## **Statistical Analysis**

Data analysis was performed using the IBM SPSS Statistics 24 software, where frequencies, percentages and crosstabs were calculated, through which the fighting times were compared with fight outcome methods, including their inherent technical–tactical actions and their form of development. Statistical significance was calculated through the chi-square test, considering the Fisher's exact value as  $p < 0.05$ .

The fight time variable was recoded into three time interval subgroups: the first subgroup from 0 s to 300 s; the second subgroup from 301 s to 599 s; and the third subgroup referring to the end of the regular time (600 s). The minimum duration time observed in the fighting was 10 s and the maximum, 600 s, referring to the total fight time, consisting of a ten-minute round (1 x 10 min).

## **Results**

### **The Fight Outcome Characterization Regarding the Methods and Occurrence Times**

The 170 fights analyzed resulted in a total time of 43,120 s (statistical average 253.65 and standard deviation 203.65), of which 33 (19.4%) fights came to an end at the regular time (600 s), that is, 19.4% fight outcomes by decision (table 1). In contrast, 117 (68.8%) fights finished during the first 5 min (300 s), where 73 (42.9%) fight outcomes were by submission, 17 (10.0%) fight outcomes were by KO, 26 (15.3%) fight outcomes were by TKO and 1 (0.6%) fight outcome was by DS (table 1). In addition, it was observed that 20 (11.8%) fights finished after 5 min (300 s) but before the regular time of the fight, of which 11 (6.5%) fight outcomes were by submission, 1 (0.6%) fight outcome was by KO, 7 (4.1%) fight outcomes were by TKO and 1 (0.6%) outcome was by DS (table 1). In the chi-square test, Fisher's exact value was considered ( $46.7\% > 20\%$ ), observing the value of 154.77 and  $p = 0.00$ , which proves that there was a statistically significant difference between the variables ( $p < 0.05$ ).

From the values presented, it is clear that there are few battles that complete the regular time, with only 19.4% fight outcomes being by decision (points scored). Most of the fights (68.8%) finished before 5 min (300 s). The submission method was the predominant fight outcome, with its highest percentage before the 300 s, followed by the decision and TKO methods, both with the same percentages, and last, by the KO method with regard to the TKO and KO methods—these mostly occurred during the first 300 s. Another method observed was the DS, with only two cases, which proves to be quite positive in terms of behaviors and regulations.

Overall, the results showed the following frequencies and percentages: 84 (49.4%) by submission, 33 (19.4%) by decision, 33 (19.4%) by TKO, 18 (10.6%) by KO and 2 (1.2%) by DS.

**Table 1.** Fight outcome characterization regarding the methods and occurrence times.

| Outcomes      | Regular Time | Before 5 min   | After 5 min   |
|---------------|--------------|----------------|---------------|
| By Decision   | 33 (19.4%)   |                |               |
| By Submission |              | 73 (42.9%)     | 11(6.5%)      |
| By KO         |              | 117<br>(68.8%) | 20<br>(11.8%) |
| By TKO        |              | 17(10%)        | 7(4.1%)       |
| By DS         |              | 26(15.3%)      | 1(0.6%)       |
|               |              | 1(0.6%)        | 1(0.6%)       |

Legend: KO = knockout; TKO = technical knockout; DS= doctor stoppage.

### The Fight Outcomes' Characterization in Terms of the Inherent Technical–Tactical Actions

From the technical–tactical actions that were at the origin of the different fight outcome methods, the following were observed (Table 2): At the submission level: 17 (10.0%) were by armbar, 29 (17.1%) by rear-naked choke, 15 (8.8%) by guillotine choke, 9 (5.3%) by triangle choke, 2 (1.2%) by leg lock, 7 (4.1%) by arm-triangle choke, 3 (1.8%) by heel hook and 2 (1.2%) by keylock.

At the KO level: two (1.2%) were by spinning back kick, two (1.2%) by high kick, nine (5.3%) by head punch, two (1.2%) by knee strike and three (1.8%) by ground and pound.

At the TKO level: 21 (12.4%) were by ground and pound and 12 (7.1%) by stand-up strikes.

**Table 2.** Fight outcomes' characterization in terms of the inherent technical–tactical actions.

| Outcomes           | Submission Level | KO Level  | TKO Level  |
|--------------------|------------------|-----------|------------|
| Armbaar            | 17 (10%)         |           |            |
| Rear-naked choke   | 29 (17.1%)       |           |            |
| Guillotine choke   | 15 (8.8%)        |           |            |
| Triangle choke     | 9 (5.3%)         |           |            |
| Leg look           | 2 (1.2%)         |           |            |
| Arm-triangle choke | 7 (4.1%)         |           |            |
| Heel hook          | 3 (1.8%)         |           |            |
| Keylock            | 2 (1.2%)         |           |            |
| Spinning Back Kick |                  | 2 (1.2%)  |            |
| High Kick          |                  | 2 (1.2 %) |            |
| Head Punch         |                  | 9 (5.3%)  |            |
| Knee Strike        |                  | 2 (1.2%)  |            |
| Ground and pound   |                  | 3 (1.8%)  | 21 (12.4%) |
| Stand- up Strikes  |                  |           | 12 (7.1%)  |

**Note:** KO = knockout; TKO= technical knockout.

### The Technical–Tactical Characterization in Terms of Development

From the technical–tactical actions observed in the fighting results, the following were observed (Table 3):

At the submission level: 60 (35.3%) actions were carried out in single attacks, 20 (11.8%) actions were carried out in combination attacks and 4 (2.4%) were carried out in counter-attacks.

At the KO level: four (2.4%) actions were carried out in single attacks, seven (4.1%) actions were carried out in combination attacks and seven (4.1%) were carried out in counter-attacks.

At the TKO level: 0 (0.0%) actions were carried out in single attacks, 33 (19.4) actions were carried out in combination attacks and 0 (0.0%) actions were carried out in counter-attacks.

It becomes clear that the fight outcomes for submission happened predominantly through technical–tactical actions carried out in single attacks; the fight outcomes by KO happened predominantly through technical–tactical actions carried out in combinations and counter-attacks; and the fight outcomes by TKO always took place through technical–tactical actions carried out in combinations attacks.

It was found that the development of the total technical–tactical actions that were at the origin of the fight outcomes before the end of the regular time were characterized by 64 (37.6%) in single development, 60 (35.3%) in combination development and 11 (6.5%) in counter-attack development.

**Table 3.** Technical–tactical characterization in terms of their development.

| Outcomes             | Submission Level | KO Level  | TKO Level |
|----------------------|------------------|-----------|-----------|
| Single Attacks       | 60 (35.3%)       | 4 (2.4%)  | 0 (0%)    |
| Combinations Attacks | 20 (11.8%)       | 7 (4.1%)  | 33(19.4%) |
| Counter-attacks      | 4 (2.4 %)        | 7 (4.1 %) | 0 (0%)    |

## Discussion

The present study aimed to characterize the fight outcomes in the Ultimate Full Contact, based on the fight outcome methods, their occurrence times, inherent technical–tactical actions and their development forms.

Overall, the results revealed that the fight outcome by submission was the most used method, followed by decision and TKO, both with the same percentages, then by KO and lastly by DS. Only 19.4% of the fights completed the regular time. In the fight outcomes by submission, chokes were the most used skills, and in the fight outcomes by KO, these happened more through head punches and kick skills, respectively, and were predominantly performed in counter-attacks and combinations. Fight outcomes by TKO occurred more through the ground and pound skill.

Therefore, the descending occurrence of the respective fight outcome methods (i.e., submission, decision, TKO and KO, respectively) is in accordance with the Fightmatrix statistical database (worldwide independent and comprehensive fighter ranking system). Considering all fight outcomes by year between 2008 and 2017, the following were observed: total fights: 173,288; submission: 67,134 (0.39); decision: 41,985 (0.24); and (T) KOs: 61,395 (0.35). In contrast, another study showed the decision as the main fight outcome reported (Antonietto et al., 2019), and this is in line with the following studies: in 174 female MMA fights, 72.4% (n = 126) fight outcomes were by the decision of the judges, 11.4% (n = 20) by submission, and 16% (n = 28) by KO or TKO (Miarka et al., 2016); the results of an MMA study that considered 304 bouts between male fighters demonstrated (n = 210) fight outcomes by decision, (n = 40) fight outcomes by submission, and (n = 54) fight outcomes by KO/TKO (Dal Bello et al., 2019). However, different results have been observed in a previous study, which demonstrated that the majority of amateur male fights ended in KO (57.7%) (Del Vecchio et al., 2011). These are differentiated results concerning the preponderance of the fight outcome methods, which can be a sequence of several factors, such as styles, gender, age, weight, physical condition, fight importance, time in the fight and time without competing (Chaabene et al., 2014; Hutchison et al., 2014; James et al., 2017). However, the preponderance of fight outcomes in the present study was based on the inherent technical–tactical actions, where the highest outcome percentages were related to fighting skills on the ground (i.e., 17.1% by rear-naked choke, 12.4% by ground and pound and 10.0% by armbar). In fact, these results are supported by an MMA study, where the winners proved to be more successful in performing the takedown when taking the fight to the ground (Kirk et al., 2015). Thus, a significant number of fight outcomes occurred due to fighting skills on the ground, which makes this style an effective combat strategy (James, Kelly, & Beckman, 2013). In line with this, grappling has been shown to play a dominant role in MMA fights, with the higher ground fighting skills being related with fight outcomes by submission, its use decreasing the number of KOs/TKOs (Dal Bello et al., 2019; James et al., 2017; Miarka et al., 2019). This means that the ability to perform the fight on the ground is an efficient strategy; that is, grappling submission proved to be a determinant style in the Ultimate Full Contact. This is because the frequencies of the fight outcomes are related to fight skills or styles (Antonietto et al., 2019; Buse, 2006; Hackett & Storey, 2017; James et al., 2017; Miarka, Vecchio, et al., 2016; Maszczyk et al., 2018).

In fact, few fights (19.4%) in the present study completed the regular time (i.e., fight outcomes by decision through points scored). This is in line with a study carried out in judo with 125 fights between men and 68 between women, which also concluded that a

significant number of fights ended before the regular time (Segedi et al., 2014). Thus, the same author suggested that the fighters should maintain a fast rhythm until the end of regular time with technical–tactical attack efficiency to increase the probability of success (Segedi et al., 2014). This means that the fighters must control decision making for their actions according the regular fight time, regulating their rhythm and interventions of attack until they can complete it. Furthermore, in the present analysis, the majority of the fights (68.8%) ended before 5 min (300 s) by submission, TKO and KO, respectively. In fact, it is known that in MMA, one-fifth of all victories through knockout before the end of the regular time occur in the first minute from the beginning of a round (Adam, Pujszo, Kuźmicki, & Szymański, 2015). In contrast, in regard to the frequency of judo dynamics in the time function, the lowest offensive activity was observed in the first minute of the fight (i.e., 0.17 with the lowest effectiveness 0.03) (Boguszewski, 2014b). These distinct fight dynamics may be related to the specific characteristics of each modality, since in the MMA rules, like Ultimate Full Contact or pankration, a wider range of technical–tactical actions is allowed when compared to judo. It should be noted that, unlike judo, in hybrid full contact combat sports, strikes are allowed, and the KO can happen at any time (Bledsoe et al., 2006; Hutchison et al., 2013). However, in the aforementioned judo study, as well as in the present investigation, the offensive activity decreased after 270 minutes, and the effectiveness decreased sharply after 260 minutes (Boguszewski, 2014b). Thus, it is understood that in combat sports in general, the activity and efficiency tend to decrease throughout the combat.

In the fight outcomes by submission, the chokes were the skills most used (i.e., rear-naked choke, guillotine choke and triangle choke, respectively), while the armbar was the most common joint lock skill. However, the fights were ended more by choke skills, these being more efficient than joint locks. Similar results were found in a previous study, which demonstrated that fight outcomes by submission resulted more from choke skills than from lock skills (Dal Bello et al., 2019). In fact, the chokes are submission skills that are applied to the neck, a vital anatomical zone that is more difficult to defend or resist than joint lock skills applied to the elbow, shoulder or knee. They interrupt the flow of blood to the brain and, in turn, its supply of oxygen, forcing the opponent to give up quickly (i.e., tap out). In the present study, these skills were developed mainly by single attacks, as also characterized by isolated skill in a previous study (Kirk et al., 2015). This means that submission techniques are usually developed in isolation/single form, since they are skills very dependent on body weight and therefore complex from a biomechanical point of view, making them difficult to perform and combine.

In the fight outcomes by KO, head punches and kicks were, respectively, the predominant skills. This is in line with another MMA study, which showed that one-fifth of all wins by knockout before the end of the regular time results were through head punches (Adam et al., 2015). In addition, in the fight outcomes by TKO, the ground and pound was the most used skill, which is in line with a study in which in ground fighting, fighters using the ground and pound, which is associated with a dominant position on the ground, had a clear tactical and technical advantage over their opponent (Adam et al., 2015). In addition, it was observed that the aforementioned skills inherent to the KO/TKO were developed mainly in combination actions and in counter-attacks; in fact, some studies mention these two fight dynamics as very efficient, although without relating them to the fight outcomes (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; El Ashker, 2017; Slimani et al., 2017; Wąsik et al., 2014).

It should be noted that the lowest incidence of the fight outcomes was by DS, with only 0.6% before 300 s and 0.6% after 300 s. From this, it can be determined that serious injuries are scarce in the Ultimate Full Contact competitions, which may be due to the experience and training of fighters and coaches (Pinto, 2015). Furthermore, the WUFC principles and regulations advocate the physical integrity of athletes as being more important than the show (Pinto, 2015).

## **Conclusions**

This investigation into fight outcomes presents relevant recommendations for coaches and fighters. The fight outcome by submission was the most used method, followed by the decision and technical knockout methods, both with the same percentages. This was followed by knockout and lastly by doctor stoppage, the latter having an insignificant value.

Most of the fights (68.8%) ended before 5 min (300 s) through submission, TKO and KO, respectively, and only 19.4% of fights completed the overall time of 10 min (600 s), ending by decision.

The fight outcomes by submission were mostly due to choke skills, using the rear-naked choke, guillotine choke and triangle choke, respectively, while the armbar was the joint lock skill most used. Regarding the fight outcomes by KO, these occurred more through head punch and kick skills, respectively, while the fight outcomes by TKO occurred more through the ground and pound skills. In addition, it was observed that the above-mentioned submission techniques are predominantly carried out in single actions; the stoppage skills by KO (e.g., head punches and kicks) are predominantly carried out in

counter-attacks and attack combinations, while the TKO is the result of skills always carried out in attack combinations.

Based on the results found, coaches will be able to develop and improve the fighters' combat performance. It will also be interesting in future studies to analyze fight outcome characterization in women athletes and other competitive categories.

### **Practical Suggestions**

Based on the results found, and in order to develop and improve fighters' performance, the following are suggested:

- Develop ground fighting skills due to their higher effectiveness;
- Stand-up strikers must develop skills that help them avoid being taken down (e.g., sprawl strategies);
- Bearing in mind that (68.8%) fight outcomes are determined during the first 5 min (300 s) and only 19.4% fights complete the regular time 10 min (600 s), it is important to increase the technical–tactical capacities and adjustable decision making to meet the regular/overall fight time;
- Develop attack combinations and counter-attack actions;
- Develop the chokes and ground and pound skills, but also their defense methods, since these skills are highly effective in ground fighting;
- Develop technical–tactical actions and fighting strategies (attacks/counter-attacks and respective defenses, e.g., head punching and dodging), taking into account the preponderance of the fight outcomes by submission and T/KO.

**Funding:** This work is supported by national funding through the Portuguese Foundation for Science and Technology, I.P., under project UIDO4045/2020.

**Acknowledgments:** The authors would like to thank the WUFC World Ultimate Full Contact – Association for the support in this investigation.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Chapter 4. General Discussion

The purpose of this thesis was to analyze the technical-tactical performance of world top-ranked fighters in ultimate full contact competition. In addition, the theoretical basis of technical-tactical behavior and its application in ultimate full contact training were characterized. The scarcity or even lack of studies on technical-tactical dynamics in ultimate full contact or in similar combat sports (i.e., pankration, free-fight, shooto, mixed martial arts) was the main reason for this investigation.

The overall results characterized ultimate full contact as a hybrid full contact combat sport of special complexity and intermittent intensity. The research carried out in this field found technical-tactical dynamics to be a determinant factor of fighters' performance, and their development is presented as a characteristic of winners. The observation of fighters in competition showed gestures and technical-tactical behaviours relevant to the analysis by coaches and fighters, which can be useful to improve the training process. These are essential demands related to offensive efficiency through combat styles and distances under cognitive and ecological approaches; to counterattack efficiency related to temporal responses; to integral characterization of fights' outcomes; to defensive efficiency; and to successful ground fighting control. This was a holistic technical-tactical approach that resulted in an integral understanding of the phenomenon.

Firstly, a review was carried out that covered published studies on technical-tactical dynamics in hybrid full contact combat sports. The main objective was to analyze the theoretical basis of technical-tactical behavior for application in ultimate full contact training, characterizing the modality under cognitive and dynamic-ecological approaches (Study 1). It was observed that knowledge of specific technical-tactical dynamics applied to hybrid full contact combat sports was very limited due to the lack of investigations related to the topic. Despite the scarcity of studies, it was found that theoretical technical-tactical knowledge obtained through competition is the only way to improve the training process efficiently. In sequence, it was identified that ultimate full contact, like MMA, can be characterized as a hybrid combat sport of special complexity and intermittent technical-tactical and physiological characteristics, using single and combined actions of different intensities with different physiological intensities (Amtmann, 2004; Chernozub et al., 2018; FPFC, 2018; Kirk et al., 2015; Pinto, 2015).

Numerous and varied skills are developed in stand-up fighting and ground fighting, creating a context of high variability, unpredictability and tenacity, where fighters can

be characterized as stand-up-strikers, ground strikers and submission grapplers (Federação Portuguesa de Full Contact, 2018; Pinto, 2015). Stand-up fighters try to keep a long or short distance by using extended full contact strikes (i.e., kicks and straight punches—jab, cross and back fist) or short full contact strikes (i.e., knees, elbows and short punches—hooks and uppercuts). Ground strikers and submission grapplers try to maintain a close distance by means of clinches, grips and takedowns, and try to end the fight through ground and pound, chokes or joint locks (Federação Portuguesa de Full Contact, 2018). This is similar to MMA, which is characterized by striking and grappling skills (punches, kicks, knees and elbow strikes, throws, takedowns, chokes and joint locks) (James et al., 2016; Kirk et al., 2015; Miarka et al., 2017), where the fighters move at a distance with free movements and full contact strikes, and in a stand-up clinch or on the ground with grips, submission grappling skills and strikes (James et al., 2016; Kirk et al., 2015; Kruyning & De Jong, 2014). Regarding fighting distances, a previous study by Miarka et al. (2017) revealed the skills and spatiotemporal changes according to actions and time to maintain combat distance, comparing fighters from different weight divisions. However, the efficiency of the different combat styles related to the various distances was not known, and it was necessary to investigate this subject better in relation to ultimate full contact (Study 2). In addition, it was relevant to analyze this subject under cognitive and dynamic-ecological approaches to better understand the technical-tactical gestures and behaviours in offensive efficiency (Study 2).

Therefore, it was observed that winners were significantly more efficient in all combat styles and distances, so this can be a decisive fight dynamic to win fights. In fact, winners showed higher efficiencies in all combat styles (stand-up strikers, ground strikers and submission grapplers) and in specific skills (e.g. kicks, knees, straight and short punches, takedowns, chokes, joint locks, ground and pound), as well as in all combat distances (long, short and close). This can be related to a larger technical-tactical repertoire and qualities such as precision, stability, versatility, adaptability and seizing opportunities in variable and unstable situations. According to what has been investigated about the best fighters at the highest fighting level, they are capable of carry out complex technical combinations (James et al., 2017); they have more creative ability for better adaptation to constant changes in the environment (Hristovski et al., 2011; Orth et al., 2017; Withagen & Van der Kamp, 2018); and they act spontaneously in accordance to contextual opportunities in a constant individual-context interaction (Araújo et al., 2006; Fajen et al., 2009; Kimmel & Rogler, 2019; Warren, 2006). However, these capacities are developed and enhanced with experience (i.e., number of fights and training time), which is associated with a cognitive process (De Dreu et al.,

2012; Delignières et al., 1998; Kostrubiec et al., 2012; Liu et al., 2006; Moraru et al., 2016; Russo & Ottoboni, 2019; Thelen, 1995).

From Study 2, it was also observed that the efficiencies of specific combat styles are highly related to the specific combat distance, which means that for greater offensive efficiency, fighters choose specific attacks according to the variation of perceptual distance. It is known through previous study that fighters strike the target with spontaneous techniques to different circumstances that is, with certain fist blows to the training bag according their movements (Hristovski et al., 2006; Hristovski et al., 2011). In addition, it has been mentioned that actions are facilitated and more frequent by reducing cognitive control or memory functioning (Dreisbach & Goschke, 2004; Memmert, 2007; Nijstad et al., 2010; Orth et al., 2017). In contrast, the data in Study 2 resulted from a competitive context, where the skills must be certain and selected according to the circumstances and the moment in order to be effective and not give opportunities to the opponent. This in line with a previous study (James et al., 2016) that showed the advantage of executing accurate techniques at an exact moment as opposed to their frequency. Therefore, it becomes important to develop automatic and technical coordination as the basis for improvement with cognitive adaptations (Bolotin & Bakayev, 2018; Mahlo, 1997). Also, the attack opportunity can be created rationally by the attacker himself, causing the opponent to attack in order to counterattack with a planned technique. This in accordance with a previous study, where fighters purposely expose their body so that the opponents attack them, with the intention of counterattacking the opponent (Ottoboni et al., 2015). In addition, high perceptual-cognitive skills must be present to adjust attacks and distances (De Quel et al., 2019) through quick adaptation to spatiotemporal changes in fights (Del Vecchio et al., 2011).

However, it is important to note that distance can be created on purpose by a fighter to attack with more efficiency. Therefore, offensive efficiency depends on the best measure between the appropriate combat distance and specific combat style. It was observed in Study 2 that the variation of distances provides different space between the fighters which obliges them to have varied dynamics and specific skills (i.e., versatility, adaptability and seizing opportunities). Consequently, fighters make decisions, choosing the appropriate combat style that is most favorable when preparing and executing specific attacks according to contextual circumstances (i.e., different distances). This is a cognitive and dynamic-ecological process that depends on fighters' skills, individual characteristics, situational constraints and strategic combat planning, which can be done by assessing strengths, weaknesses, opportunities and threats (SWOT), as many specific technical-tactical demands depend on situational factors in

terms of the strengths and weaknesses of fighters (Antonietto et al., 2019; Bakaev et al., 2016; Dal Bello et al., 2019; Fernandes et al., 2018; Filimonov et al., 1985; Ghoul et al., 2017; James et al., 2017; Maszczyk et al., 2018; Miarka et al., 2016).

Regarding the offensive styles used by fighters in combat, the submission grappler has been shown to be the most efficient style, followed by the ground striker and stand-up striker, respectively. In fact, grappling activity and accurate techniques have proved to be important dynamics to win fights (James et al., 2017). However, in terms of the specific skills of each style, punches and kicks by the stand-up striker are more efficient actions than chokes and joint locks by the submission grappler. Nevertheless, it is important to emphasize that these values of punches and kicks were obtained through the relationship between the effective actions performed, which, although they were more efficient in terms of the high number of effective blows, were not the ones that ended most fights. This was largely down to submission skills, mainly chokes, as shown in Study 5. It is understandable that the effectiveness of the strikes contributes to confuse and weaken the opponent and better submit him, and winners were those who more efficient in both submission skills and stand-up striking skills.

One specific skill of ground fighters (i.e., ground strikers and submission grapplers), the takedown skill, was the most efficient of all the fighting skills. This is in line with an MMA study that revealed its high efficiency, the takedown skill being recommended to improve fighters' performance (Miarka, 2017). This technique is usually used in stand-up fighting to take the opponents down and attempt to end the fight through chokes, joint locks, or ground and pound. In fact, takedown is a specific skill that connects stand-up grappling with ground submission grappling, this relationship being a vital condition for the ground fighter's performance (Del Vecchio et al., 2011; Miarka, Coswig, et al., 2016; Miarka, Fukuda, et al., 2016; Miarka et al., 2017; Sterkowicz-Przybycień et al., 2017)

Furthermore, an attack can be developed during a counterattack as a defensive action: these are fighting skills with strong technical and tactical characteristics (i.e., biomechanical and bio-informational constraints). However, the counterattack requires a very strict tactical procedure and it has not been sufficiently investigated in combat sports in general. Thus Study 3 analyzed one of the counterattack's greatest features, the efficiency of temporal response to the opponent's attack in combat. Study 3 showed that it was the winners who stood out in all counterattack effectiveness related to different response times (i.e., anticipation, simultaneous and posterior). The anticipated counterattack was carried out most by winners and was also the most efficient, followed by the simultaneous counterattack and then the posterior counterattack, this frequency order being reversed for losers. However, the efficiency

order of counterattack temporal responses was the same for winners and losers. Curiously, it was observed that losers carried out the posterior counterattack more often than winners but with less effectiveness, maybe due to their lower performance related to less experience.

Nevertheless, the counterattack proved to be a very efficient fight dynamic in all temporal responses, but particularly the anticipated form, which showed 100 per cent effectiveness. Thus, anticipation is revealed as an essential demand for fighters' performance in ultimate full contact competition. This skill may be related to the greater experience of winners, consequently with more refined perceptual-cognitive ability to perceive, decide and anticipate (Abernethy & Russell, 1987; De Quel et al., 2019; McRobert et al., 2011; North et al., 2009; Russo & Ottoboni, 2019; Williams et al., 2010). This means that they have the ability (i.e., the perceptual-cognitive skills) to identify opportunities and the knowledge to select and respond in anticipation with appropriate techniques (Marteniuk, 1976; Russo & Ottoboni, 2019). In fact, qualities such as memory, attention, concentration, discernment, resolution and decision-making are essential cognitive skills to perceive and anticipate (De Dreu et al., 2012; Mahlo 1997; Mann et al., 2007). There is an ongoing cognitive process throughout the fight to perceive attacks either before they start or while they are happening (De Quel et al., 2019), respectively associated with anticipated or simultaneous counterattacks.

Counteroffensive actions require defensive actions to have been performed immediately before; therefore, basic defensive actions such as jamming, dodging, slipping and displacement (the most successful defenses by the winners—Study 4) are mostly associated with anticipated or simultaneous counterattack, are more efficient than blocking or parrying, and are usually mostly associated with posterior counterattack. In addition, Study 3 showed that the biggest difference between winning or losing was with regard to the efficiency of anticipated and simultaneous counterattacks, but not the efficiency of posterior counterattacks. However, in general, counterattack efficiency proved to be a significant technical-tactical dynamic in the winning or losing effect, so it is a decisive and determinant action in the ultimate full contact fighter's performance. The same is seen in different combat sport studies, which reported the counterattack as an efficient skill revealed by the best fighters and winners (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska 2006; Hao, 2019; Vidranski et al., 2015).

In addition to offensive and counteroffensive efficiency, it is important to consider defensive efficiency and ground fighting control, since even in an attack, defense must be assured by the attacker so as not to be hit by an opponent's counterattack (Study 4). The best fighters associate offensive actions with defensive actions (Adam &

Sterkowicz-Przybycień, 2018; El Ashker, 2011; Forbes & Kolliopoulos, 2004). Winners were also more active and efficient, indicating that defensive skills and ground fighting control are vital technical-tactical dynamics for higher performance in ultimate full contact. Indeed, they have been highlighted as technical-tactical characteristics of winners in several combat sports (Boguszewski, 2014a, 2014b, 2016; Boguszewski & Boguszewska, 2006; Kassim et al., 2015). Of the defensive resources, evading (i.e., dodging, slipping and displacement), escaping, sprawling and parrying were more efficient skills revealed by winners, while blocking was more prevalent among losers. The defensive skills presented by winners are suitable actions (i.e., evasion) to avoid the impact while allowing them to keep their arms/hands and legs/feet available for counterattack; the losers' defensive skill (blocking) is performed more simply and is easier to use in critical situations. This is in accordance with Urquidez (1981), who mentioned blocking as a defensive action that requires from the fighters the use of both arms to cover them, leaving them unavailable for an attack: when using this defense, it should not be maintained for long, but should be a quick block and attack. Accordingly, evading skills (dodging, displacement, slipping, jamming) are most recommended as a defensive strategy in full contact fighting, as this way it is possible to maintain adequate distance and balance to deliver an attack/counterattack with more precision and effectiveness (Lee, 1975; Urquidez, 1981; Wallace, 1982). Study 2, where the adjustable interaction between styles/skills and distances was observed for the most efficiency, is in line with Study 3, where the most efficient forms of counterattack were anticipated and simultaneous to the opponent's attack, for which the basic defenses should be evading (dodging, slipping or displacement).

Moreover, winners also revealed more defensive efficiency in sprawling and escaping—that is, they showed greater ability to avoid being taken down or submitted in ground fighting. In fact, Study 2 mentioned offensive ground fighting styles (i.e., the submission grappler and the ground striker) as the most efficient fighting dynamic revealed by winners, which indicates that they are the ones with the most ability to make the best decision at the right time. Just as takedowns and submission skills were shown to be an advantage in winners, so they defend themselves from opponents' attempts and have the ability to take down and end fights by submission or strikes at the most appropriate moment.

In addition, when the fight is played out on the ground, winners are characterized by their greater ability to assume dominant positions in the ground fighting (i.e., mount control, side control and back control), forcing losers to take more defensive actions (i.e., closed guard, immobilization, reversals/sweeps and half guard). Thus, the winners' fighting strategy while ground fighting is more stable and favorable to strike

or submit the opponent. This in line with what has been published on MMA (Adam et al., 2015; Del Vecchio et al., 2011). The data in Study 2 are also in accordance with this, since ground fighting styles and their offensive skills (chokes, joint locks, and ground and pound) were performed more efficiently by winners.

Looking at the difference between winning or losing, evading and sprawling in defense and mount, side control and back control in ground fighting control were the most significant skills. Consequently, it is known from Study 1 that fight outcome analysis disseminates information about fighters' skills, since the way the fighting ends can reveal the athletes' styles and type of training (Antonietto et al., 2019; Dal Bello et al., 2019; Hutchison et al., 2014; James et al. 2017; Miarka et al., 2016). However, no investigation has been carried out holistically to compare fights' outcomes in terms of their methods, inherent skills, developments and their occurrence times in the fight. Thus, there was a need to carry out Study 5 to provide a comprehensive view and general understanding of the technical-tactical behavior, the results of which confirmed the conclusions of previous investigations (Studies 1, 2, 3 and 4). In terms of fights' outcomes, submission was the method most used to win (in line with Study 2, that proved ground fighting to be a more efficient style). The second most efficient terminations were decisions and technical knockouts, with the same percentages, followed by knockout and then doctor stoppage. This order is in accordance with the offensive efficiency related to fighting styles and distances (Study 2), where the mostly of the fights (68.8%) ended before five minutes (300 seconds) by submission, technical knockout and knockout, in that order; only 19.4 per cent of fights completed the regular combat time of ten minutes (600 seconds), ending by decision. A recent study in MMA showed that the activity also decreases from one five-minute round to the next (Miarka et al., 2019). However, this is not fully representative of ultimate full contact, since in this modality the combat takes place in a single round of ten minutes: there is no pause. Consequently, through the skills inherent in the different fights' outcomes, it was possible to obtain confirmation of the previous studies (Studies 1, 2, 3 and 4). Thus, the fights that ended by submission skills were mainly carried out in individual actions, and the preponderant skills were chokes (rear-naked choke, guillotine choke and triangle choke, respectively), while the armbar was the most used joint lock. In the fights that ended by knockout, the strikes were mainly carried out in counterattacks and attack combinations, the skills most responsible being head punches and kicks skills respectively, while in fights ending in technical knockout, the strike skills were always carried out in attack combinations, mainly through ground and pound.

Furthermore, it was particularly interesting to know, that only 1.2% of the fights ending by doctor stoppage, indicating that the modality is safe despite being a hybrid full

contact combat sport. This may be a consequence of the high level of involvement of sports agents in terms of experience and training, as well as WUFC regulations, where it is advocated that all development should respect the martial arts/sports principles, and the physical integrity of the fighters is more important than the spectacle. Sarmiento (2005) expressed that the sport must be a process of values, ethics and development, determined by variables that supersede the sporting show itself.

## **Practical Applications**

Finally, based on the results of studies 1, 2 3, 4 and 5, it was recommended that ultimate full contact fighters develop a large and versatile technical-tactical repertoire in an integral and balanced way of all fighting dynamics (i.e., offensive, counteroffensive, defensive and control), and qualities such as anticipation, quick perception/ interpretation, spatiotemporal-synchronization, adaptation, adequate decision-making, technique automation, combination skills, situational adaptability, seizing opportunities, timing, unpredictable actions, distance measurement, balance, displacements, efficiency, precision and power. These determinant skills should be trained to improve and develop the ultimate full contact fighter's performance. Therefore, for the operationalization of strategic planning and effective training, it is essential to consider the outcomes of all of the studies carried out within this thesis, which bring new and useful information about all technical-tactical dynamics that can certainly help coaches to increase fighters' performance.

It is suggested that training processes be developed based simultaneously on cognitive and dynamic-ecological models to improve qualities such as memory, concentration, attention, and situational adaptation and creativity. The training should include the wide and varied technical-tactical resources representative of competition, focusing on the more efficient skills of offensive, counteroffensive and defensive dynamics (i.e., attack combinations, anticipated and simultaneous counterattacks, takedowns, punching, kicking, chokes, ground and pound, evading, sprawling, escaping, mount, back control, and side control); and on articulating different combat styles/skills and distances with appropriate measures between them (i.e., stand-up striker style with straight punches and kicks skills—long distance; stand-up striker style with short punches and knees skills—short distance; ground striker style with takedowns and ground and pound skills—close distance; submission grappler style with takedowns, chokes and locks skills—close distance), along with the respective defensive and control skills. In addition, the regulation of decision-making during the fight is very important to increase the capacity to comply with the regular fighting time (i.e., the total time of the fight – one round of 10 minutes).

The training should use methods where analytical and integrated exercises coexist, through systematic technical-tactical repetition in pair training (i.e., one-to-one) and formal or fractional sparring (i.e., competition representative); or an analytical and integrated mix, through a plastrons/focus mitts workout with an experienced trainer who intentionally favors one of the technical or tactical dimensions; or both in a balanced way, with the advantage of being able to look immediately at certain details (i.e., critical points). Such a training method is very effective in that the trainer can assume the role of an opponent, interacting with the fighter, which makes it easier to assess his performance in a contextualized way and improve him. These training process can promote efficient and representative technical-tactical structural and functional development (i.e., automation, precision, stability, versatility, adaptability, perception, timing, decision-making and seizing opportunity). However, although technical-tactical aspects are decisive for the performance, the physical component can be a conditioning factor; thus, through the technical-tactical training, all other skills—physical, psychological and socio-affective—should be properly developed. That is to say, the technical-tactical exercises must be developed according to the physiological load to obtain adjustable physical adaptations (e.g. technical exercises under interval or intermittent training). It should be noted that planning of the proposed training method starts after an assessment according to pre-established objectives to find the development level of the fighters.

The main limitation of this thesis includes the following:

- i. The studies were based on viewing videos from just one angle, having images from more than one angle could result in even more accurate observations.
- ii. Lack of previous research studies on the ultimate full contact combat sport.



## Chapter 5. Overall Conclusions

This thesis emphasizes an integral vision and a general understanding of the technical-tactical actions and behaviours in the competitive ultimate full contact context—that is, in respect of efficiency in offensive, counteroffensive, defensive and control dynamics. The representative knowledge obtained allows training processes to be improved, and consequently optimization of fighters' performance. As a general conclusion of the many specificities obtained in the studies carried out in relation to combat dynamics, the following can be determined as relevant in the guide to training structures.

Firstly, modality characterization is an important factor to consider in training plans, as ultimate full contact is a hybrid full contact combat sport of special complexity, interspersing diverse simple and combination actions developed in stand-up fighting and/or ground fighting with an intermittent technical-tactical and physiological load. Technical-tactical factors become decisive, and the physical factor becomes a condition for success in combat, where tenacity, variability and unpredictability prevail. Therefore, it is advisable to carry out the training through technical-tactical exercises with adjusted physical loads so that, through these exercises, the fighters can obtain the necessary physiological adaptation with the recommended interval or intermittent training. Although tactical behavior is decisive, it is necessary to emphasize the technical role in combat, due to their high diversity. In fact, when a fighter performs a technique poorly (e.g. unprotected, inaccurate) or inappropriately (in terms of timing or opportunity), the technique may not achieve its objective, or the fighter can suffer a knockout, which increases the emotional pressure on fighters (i.e., affective-emotional conditions). Thus, it is necessary to develop training under cognitive and dynamic-ecological approaches through analytical training, integrated or mixed (e.g. technical repetitions, sparring or plastrons/focus mitts workout) with the objective of increasing the technical-tactical repertoire and the fighter's biomechanical, perceptual-cognitive and bio-informational qualities.

The investigation showed that winners were more efficient in all combat dynamics. Thus, as a fighting strategy, for offensive actions to be effective, fighters must consider their style and skill according to the different perceived combat distances. They can also create appropriate distances themselves through displacements and stances to attack more efficiently—that is, they can rationally create their opportunities. In this regard, it was found that styles and skills are related as follows: the stand-up striker style uses kicks and straight punches (long distance), as well as short punches and knee skills (short distance); the ground striker style uses takedowns, and ground and pound skills

(close distance); and the submission grappler style uses takedowns, chokes and joint locks (close distance). The submission grappler and ground striker styles are the most efficient, followed by the stand-up striker; however, punching and kicking proved to be more efficient than submission techniques. Effective kicking and punching do not always end the fight by a knockout or technical knockout, though, while submission skills, when they are effective, do end the fight. It should be noted that the most efficiency in both striking and submission skills was seen in winners. This indicates that all skills should be interrelated to be successful.

The greater efficiency of ground fighting is due to the high efficiency of takedowns, considered the fundamental technique that links stand-up fighting with ground fighting. Chokes were the most efficient submission technique. These conclusions are in line with those regarding defensive efficiency and successful ground fighting control, and, in turn, the different counteroffensive efficiencies and their temporal response to opponents' attacks. Thus, it was determined that the most efficient defenses were evading (dodging, slipping, displacement, jamming), sprawling and escaping. In line with the offensive actions, winners were more efficient in stand-up fight defense, avoiding being taken down. Furthermore, the anticipated counterattack (100% efficient) and the simultaneous counterattack proved to be the most efficient forms, being executed further to the basic defense of evasion. In turn, the losers proved to be more efficient only in blocking and in the posterior counterattack, actions that are related and are less effective, since blocking requires the use of both arms to cover the fighter, making them unavailable to carry out an anticipated or simultaneous counterattack.

In ground fighting control, the winners showed more success in mount, back control and side control, while the losers showed more success in guard and half guard. This means that the winners, while in the fight on the ground, take dominant positions to strike or subdue the opponent, while the losers are forced to act defensively. Finally, the way the fights ended is in line with what happened in all studies: most of the fights ended with submission techniques, mainly through chokes. There are few battles that comply with the regular time of the fight and the vast majority end before the first five minutes. In this respect, it is suggested to develop the decision-making related to actions and intensities according to the regular fight timing.

Through skills inherent to the different fight outcome, it was found that submission techniques were performed mainly in isolation, while the strikes responsible for knockouts were generally developed in combinations and in counterattacks. The strikes leading to technical knockouts were always developed in combinations, mainly through ground and pound. Briefly, for the technical-tactical performance to be efficient in

fighting requires the integrated and balanced development of all dynamics, since they are interconnected. Among other qualities of technical-tactical performance, some—versatility, adaptability, automation, seizing opportunities, anticipation, unpredictability, timing, perception, decision-making, combinations, balance, precision, displacement, and appropriate interaction between styles, skills and distances—stand out.

## **Winners' Profile**

The conclusions allow to outline the profile of winners. They are versatile in their fighting styles and skills. They have the ability to adapt to contextual variability (distances) and to take advantage of opportunities to be effective in offensive, counteroffensive, defensive and control dynamics, and they can act with adjusted actions at the right time: at long distance, they favor straight punches and kicks; at short distance, they favor short punches and knees strikes; at close distance, they favor takedowns; and when fighting on the ground, they have the ability to control, taking dominant positions (i.e., mount, back control, side control) that allow them to finalize their opponents with submission or strikes skills, especially with chokes and ground and pound. Winners favor attacks in combinations and opt for anticipated (100% effectiveness) and simultaneous counterattacks, always keeping in mind defensive resources, especially evading (i.e., dodging, slipping, displacement, jamming) and use sprawling and escaping as a way to avoid the impact and the opponent's intention to take the fight to the ground. Ground fighting is the most efficient style; however, it is supported by the efficiency of stand-up fighting.

Using the knowledge obtained in this study, it is possible for coaches of all hybrid full contact combat sports to optimize their training methodologies and improve fighters' performance.



## **Chapter 6. Suggestions for future investigations**

This study provides holistic knowledge of the technical-tactical demands of ultimate full contact which is very useful for coaches organizing training plans with methods representative of competition. This can increase and develop fighters' performance. Thus, future research into technical-tactical skills on hybrid full contact combat sports should make use of the developments found.

The following are some suggestions that we consider relevant for possible future investigations:

- I. To replicate the studies performed in this thesis with other combat sports.
- II. To continue to develop knowledge of the confluence of cognitive and dynamic-ecological approaches to technical-tactical actions in combat.
- III. To clarify the effect of winning or losing, comparing all fighting dynamics (offensive, counteroffensive, defensive and ground fighting control).
- IV. To compare the efficiency of all technical-tactical dynamics shown by the winners to know whether more offensively or defensively.
- V. To clarify the process of cognitive perception and decision-making on attack/counterattack (i.e., observation, interpretation, preparation, and execution) related to opportunities and anticipation actions.
- VI. To understand the regulation of effort in the different technical-tactical skills (e.g. punching, kicking, takedown, sprawling) and styles (stand-up striker, ground striker and submission grappler).
- VII. To analyze the technical-tactical dynamics (offensive, counteroffensive, defensive and ground fighting control) associated with physiological demands.



# Chapter 7. References

## Chapter 1. General Introduction

Adam, M., Pujszo, R., Stanisław, K., Szymański, M., & Tabakov, S. (2015). MMA fighters' technical-tactical preparation – fight analysis: a case study. *Journal of Combat Sports and Martial Arts*, 6, 35-41. 10.5604/20815735.1174229.

Adam, M., Klimowicz, P., & Pujszo, R. (2016). Judoists' tactical and technical efficiency during the World Championships in 2014 and 2015. *Baltic Journal of Health and Physical Activity*, 8(2), 19-28.

Adam, M., Smaruj, M., & Tyszkowski, S. (2011). The diagnosis of the technical-tactical preparation of judo competitors during the world championships (2009-2010) in the light of new judo sport rules. *Archives of Budo Science of Martial Arts*, 7, 5-8.

Afonso, J., Garganta, J., & Mesquita, I. (2012). Decision-making in sports: the role of attention, anticipation and memory. *Brazilian Journal Kinanthropometry and Human Performance*, 14(5), 592-601.

Amtmann, J.A. (2004). Self-reported training methods of mixed martial artists at a regional reality fighting event. *The Journal of Strength and Conditioning Research*, 18, 194-196.

Atan, T., & İmamoğlu, O. (2005). Competition analysis of world greco-roman and world free-style wrestling championships. *International Journal of Performance Analysis in Sport*, 5(1).

Avakian, S.P., Miarka, B., & Achour, A.J. (2017). Análise de frequência das ações técnico-táticas competitivas no taekwondo: uma revisão. *Revista de Artes Marciales Asiáticas*, 11(2), 83-98.

Badilin, A. (2014). Training process management based on a complex statistical estimation of curlers competitive activity. VIII International Scientific and Practical Conference of Students and Young Scientists. *Modern University Sport Science*. The

Lesgaft National State University of Physical Education, Sport and Health, Saint Petersburg.

Barna, T. (2013). Elite wrestlers' orientation to tactical information. *International Journal of Wrestling Science*, 3(1), 10-16.

Boguszewski, D. (2014a). Dynamics of judo contests performed by top world judokas in the years 2008-2012. *Journal of Combat Sports and Martial Arts*, 1(2), 31-5.

Boguszewski, D. (2014b). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-6.

Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sports and Martial Arts*, 1(2), 67-72.

Boguszewski, D., & Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). *Archives of Budo*, 2, 40-4.

Bolotin, A., & Bakayev, V. (2018). Pedagogical practice for development of coordination potential of MMA fighters and estimation of its efficiency. *Journal of Human Sport and Exercise*, 13(1), 72-88. doi:<https://doi.org/10.14198/jhse.2018.131.08>

Cappai, I., Pierantozzi, E., Tam, E., Tocco, F., Angius, L., Milia, R., Squatrito, S., Concu, A., & Crisafulli, A. (2012). Physiological responses and match analysis of Muay Thai fighting. *International Journal of Performance Analysis in Sport*, 12(3), 507-516.

Castelo, J., Barreto, H., Alves, F., Santos, P.M., Carvalho, J., & Vieira, J. (1996). *Metodologia do treino desportivo* (1st ed). Lisboa: Universidade Técnica de Lisboa FMH.

Chen, W.Y., Wu, S.K., Song, T.F., Chou, K.M., Wang, K.Y., Chang, Y.C., & Goodbourn, P.T. (2017). Perceptual and motor performance of combat-sport athletes differs according to specific demands of the discipline. *Perceptual and Motor Skills*, 124(1), 293-313. doi:[10.1177/0031512516681342](https://doi.org/10.1177/0031512516681342)

Davis, P., Wittekind, A., & Beneke, R. (2013). Amateur boxing: activity profile of winners and losers. *International Journal of Sports Physiology and Performance*, 8(1), 84-91.

De la Fuente, A., & Castejón, F. (2016). An evaluation of categories for tactical actions: A preliminary study of combat analysis in taekwondo. *Cultura Ciencia Deporte*, 11(32), 157-170.

Del Vecchio, F., Hirata, S., & Franchini, E. (2011). A Review of time-motion analysis and combat development in mixed martial arts matches at regional level tournaments. *Perceptual and Motor Skills*, 112(2), 639-648.

El Ashker, S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing. *International Journal of Performance*, 1(2), 356-64.

Faro, H.K., Fortes, L.S., & Machado, D.G. (2020). Dynamics of cognitive performance at rest and after exhaustive exercise in top-three world-ranked mixed martial arts athletes: a series of case studies. *Journal of Sports Medicine and Physical Fitness*, 60(4), 664-668.

Federação Portuguesa de Full Contact, FPFC. (2018a). História e desenvolvimento do full contact em Portugal. Available from: <http://www.angelfire.com/pq/fppff/ultimatefullcontact.htm>

Federação Portuguesa de Full Contact, FPFC. (2018b). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available from: <http://www.angelfire.com/pq/fppff/description.htm>

Franchini, E., & Del Vecchio, F. (2010). Judo and variability: Application to technical actions during the match. In: Warnick, J., Martin, W. (Eds.). *Advancements in the Scientific Study of Combative Sports*. Hauppauge: Nova Science, 1, 79-96.

Franchini, E., Matsushigue, K.A., Del Vecchio, F.B., & Artioli, G.G. (2011). Physiological profiles of elite judo athletes. *Sports Medicine*, 41(2), 147-166.

Franchini, E., Sterkowicz, S., Meira, C., Gomes, F., & Tani, G. (2008). Technical variation in a sample of high-level judo players. *Perceptual and Motor Skills*, *106*(3), 859-69.

Franchini, E., & Takito, M.Y. (2014). Olympic preparation in brazilian judo athletes: description and perceived relevance of training practices. *Journal of Strength and Condition Research*, *28*(6), 1606-1612.

Gierczuk, D., & Bujak, Z. (2013). The analysis of coordination training means used in the training of wrestlers. *Journal of Combat Sports and Martial Arts*, Medsportpress; *1*(2), Vol. 4, 19-23. doi: 10.5604/20815735.1072230.

Hao, Y.A. (2019). Brief discussion on counter attack tactics and application technique in the sanda competition. *Frontiers in Sport Research*, *1*(2), 47-53.

Hutchison, M.G., Lawrence, D.W., Cusimano, M.D., & Schweizer, T.A. (2014). Head trauma in mixed martial arts. *American Journal Sports Medicine*, *42*(6), 1352.

Ito, K., Hirose, N., Nakamura, M., Maekawa, N., Tamura, M., & Hirotsu, N. (2013). The transformation of technical-tactical behaviors from hand techniques used in attacking below belt after the 2010 International Judo Federation rule revision. *Archives of Budo Science of Martial Arts*, *9*, 1-6.

Ito, K., Hirose, N., Tamura, M., & Nakamura, M. (2015). Alterations in kumite techniques and the effects on Score rates following the 2013 International Judo Federation rule revision. *Archives of Budo Science of Martial Arts*, *11*, 87-92.

Jaspe, J.S.R., Del Vecchio, F., Picanço, L.M., & Takito, M.Y. (2011). Time–motion analysis in muay-thai and kick-boxing amateur matches. *Journal of Human Sport & Exercise*. Faculty of Education. University of Alicante, *6*(3), 1988-5202.

Kalina, R.M. (2000). *Teoria sportów walki*. COS, Warszawa.

Kazemi, M., Perri, G., & Soave, D. (2006). A profile of Olympic taekwondo competitors. *Journal of Sports Science and Medicine*, *114*-21.

Keller, V.S., & Tyshler, D.A. (1972). *Trenirovka fekhtovalshchikov* [Fencer training]. Moscow: Physical Culture and Sports, 182.

Kirk, C., Hurst, H., & Atkins, S. (2015). Comparison of the training loads of mixed martial arts techniques in isolated training and open sparring. *Journal of Combat Sports and Martial Arts*. *Medsportpress*, 1(2), vol. 6, 15-20. doi: 10.5604/20815735.1174226.

Koropanovski, N., Dopsaj, M., & Jovanović, S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biometricity*, 2(4), 241-51.

Koroponovski, N., & Jovanović, S. (2007). Model characteristics of combat at elite male karate competitors. *Serbian Journal of Sports Sciences*, 1(3), 97-115.

Krabben, K., Orth, D., & Van der Kamp, J. (2019). Combat as an interpersonal synergy: An ecological dynamics approach to combat sports. *Sports Medicine*, 49, 1825-1836. doi.org/10.1007/s40279-019-01173-y

Kruszewski, M., Kruszewski, A., Kuźmicki, S., Sklepiński, L., Kępa, G., & Landowski, K. (2016). Boxing techniques based on the analysis of boxing tournament finals during Olympic Games in London in 2012. *Journal of Combat Sports and Martial Arts*. *Medsportpress*, 1(2), Vol. 7, 61-66. doi: 10.5604/20815735.1224961.

Lee, L. (1975). *Tao of jeet kune do by Bruce Lee* (1st ed). CA: Ohara Publications, Inc.

López-González, D. (2014). Technical-tactical performance in greco-roman wrestling: analysis of 2013 Senior World Championships through multivariate analysis. *International Journal of Wrestling Science*, 4(1), 95-110.

López-González, D.E., & Miarka, B. (2013). Reliability of a new time-motion model based on technical-tactica interactions for wrestling combats. *International Journal of Wrestling Science*, 3, 21-34.

Mahlo, F. (1997). *Acto tático no jogo* (1st ed). Lisboa: Compendium.

Malkov, O.B., & Ramashov, A.A. (2019). Key differences in combat tactics, action triggers and self-commands in taekwondo and boxing. Available from: [www.teoriya.ru/ru/node/8619](http://www.teoriya.ru/ru/node/8619)

Menescardi, C., Falco, C., Estevan, I., Ros, C., Morales-Sánchez, V., & Hernández-Mendo, A. (2019). Is it possible to predict an athlete's behavior? The use of polar coordinates to identify key patterns in taekwondo. *Frontiers in Psychology*, 10, 1232

Menescardi, C., Falco, C., Hernández-Mendo, A., & Morales-Sánchez, V. (2020). Talent and creativity of taekwondoists winners of the 2016 Summer Olympics. *Sustainability*, 12, 4185. doi:10.3390/su12104185

Menescardi, C., Liebana, E., Liebana, E., & Falco, C. (2019a). Why do female and male taekwondo athletes win the bout? An analysis based on the Olympic weight category and the result of the bout. *Revista de Artes Marciales Asiáticas*, 14(2), 67-82. doi: 10.18002/rama.v14i2.6051

Miarka, B. (2016). Demandas técnico-táticas e fisiológicas de combates da luta Olímpica. *Revista de Artes Marciales Asiáticas*, 11(1), 18-31. doi: 10.18002/rama.v11i1.3309

Miarka, B., Brito, C.J., Dal Bello, F., & Amtmann, J. (2017). Motor actions and spatiotemporal changes by weight divisions of mixed martial arts: Applications for training. *Human Movement Science*, 55, 73-80.

Miarka, B., Fukuda, D., Vecchio, F., & Franchini, E. (2016). Discriminant analysis of technical-tactical actions in high-level judo athletes. *International Journal of Performance Analysis in Sport*, 16, 30-39.

Miarka, B., Julio, U.F., Del Vecchio, F.B., Calmet, M., & Franchini, E. (2010). Técnica y táctica en judo: una revisión. *Revista de Artes Marciales Asiáticas*, 5(1), 91-112.

Miarka, B., Pérez, D.I.V., Aedo-Muñoz, E., da Costa, L.O.F., & Brito, C.J. (2020). Technical-tactical behaviors analysis of male and female judo cadets' combats. *Frontiers in Psychology*, 11, 1389.

Milazzo, N., Farrow, D., & Fournier, J.F. (2016). Effect of implicit perceptual-motor training on decision-making skills and underpinning gaze behavior in combat athletes. *Perceptual and Motor Skills*, 123(1), 300-23.

Mori, S., Ohtani, Y., & Imanaka, K. (2002). Reaction times and anticipatory skills of karate athletes. *Human Movement Science, Amsterdam*, 21(2), 213-30.

Ouergui, I., Hssin, N., Franchini, E., Gmada, N., & Bouhlef, E. (2013). Technical and tactical analysis of high level kickboxing matches. *International Journal of Performance Analysis in Sport*, 13(2), 294-309.

Petri, K., Bandow, N., Salb, S., & Witte, K. (2018). The influence of facial expressions on attack recognition and response behaviour in karate kumite. *European Journal of Sport Science*, 1-10. <https://doi.org/10.1080/17461391.2018.1536170>.

Pinto, F.C.L. (2015). *Perceção sobre as competências do treinador de desportos de combate (Master's Thesis)*. Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Rodríguez, A.R, Rodríguez J.R, Fuentes-Guerra F.J.G, & Robles, M.T.A. (2018). Importancia del entrenamiento técnico-táctico y de condición física en el de proceso de formación los judokas olímpicos españoles. *Revista de Artes Marciales Asiáticas*, 13(2s), 1719-2018. doi: 10.18002/rama.v13i2s.5499

Romashov, A.A. (2019). Tactical features of using counter attack in professional boxing. *Uchenye zapiski universiteta imeni P.F. Lesgafta*, 3(169), 271-74.

Russo, G., & Ottoboni, G. (2019). The perceptual - Cognitive skills of combat sports athletes: A systematic review. *Psychology of Sport and Exercise*, 44, 60-78.

Santos, V., Franchini, E., & Lima-Silva, A. (2011). Relationship between attack and skipping in taekwondo contests. *Journal of Strength and Conditioning Research, Champaign*, 25(6), 1743-51.

Sherdog. (2017). Organizations: World Ultimate Full Contact. Available from: <https://www.sherdog.com/organizations/World-Ultimate-Full-Contact-955>

Shih, Y.L., & Lin, C.Y. (2016). The relationship between action anticipation and emotion recognition in athletes of open skill sports. *Cognitive Processing*, 17(3), 259-268. <https://doi.org/10.1007/s10339-016-0764-7>.

Śledziwski, D., Łoniewski, M., Kuder, A., Silva, R., Pedrosa, G., Couto, B., & Szmuchrowski, L. (2015). Fighting profiles in men's taekwondo competition in the under 68 kg category at the Olympic Games in Beijing (2008) and London (2012) – Case Studies. *Budo Science of Martial Arts and Extreme Sports*, 11, 1-9.

Slimani, M., Chaabène, H., Davis, P., Franchini, E., Cheour, F., & Chamari, K. (2017). Performance aspects and physiological responses in male amateur boxing competitions: A brief review. *Journal of Strength and Conditioning Research*, 31(4), 1132-1141. doi: 10.1519/JSC.0000000000001643

Tod, D., Edwards, C., McGuigan, M., & Lovell, G. (2015). A Systematic review of the effect of cognitive strategies on strength performance. *Sports Medicine*, 45, 1589-1602.

Urquidez, B. (1981). *Training and fighting skills* (1st ed). CA: Unique Publications, Inc.

Veiga, R. (Realizador), & Companhia de Ideias (Produtor). (2009). *Vale Tudo – As opções de São Mateus: A história de um campeonato do mundo muito particular...* [Documentário TV]. Lisboa: RTP. Available from: <http://www.rtp.pt/programa/tv/p25602>

Vidranski, T., Maškarin, F., & Jukić, J. (2015). Differences in technical and tactical indicators of attacks and counterattacks in elite male karate fighters. *Acta Kinesiologica*, 1 (9), 19-24.

Wallace, B. (1982). *Dynamic stretching & kicking* (1st ed). CA: Unique Publications, Inc.

Wąsik, J., Pieter, W., & Borysiuk, Z. (2014). The effect of offensive and defensive actions on taekwondo sparring. *Journal of Combat Sports and Martial Arts*, 5(2), 27-30.

World Ultimate Full Contact, WUFC. (2017). World Rankings. Available from: <http://ultimatefullcontact.tripod.com/wufrankings.htm>

## **Chapter 2. Literature Review**

Adam, M., Klimowicz, P., & Pujszo, R. (2016). Judoists' tactical and technical efficiency during the World Championships in 2014 and 2015. *Baltic Journal of Health and Physical Activity*, 8(2), 19-28.

Adam, M., Pujszo, R., Stanisław, K., Szymański, M., & Tabakov, S. (2015). MMA fighters' technical-tactical preparation – fight analysis: a case study. *Journal of Combat Sports and Martial Arts*, 6, 35-41. 10.5604/20815735.1174229.

Adam, M., Smaruj, M., & Tyszkowski, S. (2011). The diagnosis of the technical-tactical preparation of judo competitors during the world championships (2009-2010) in the light of new judo sport rules. *Archives of Budo Science of Martial Arts*, 7, 5-8.

Adam, M., & Sterkowicz-Przybycień, K. (2018). The efficiency of tactical and technical actions of the national teams of Japan and Russia at the world championships in Judo (2013, 2014 and 2015). *Biomedical Human Kinetics*, 10, 45.

Afonso, J., Garganta, J., & Mesquita, I. (2012). Decision-making in sports: the role of attention, anticipation and memory. *Brazilian Journal Kinanthropometry and Human Performance*, 14(5), 592-601.

Abernethy, B., & Russell, D.G. (1987). The relationship between expertise and visual search strategy in a racquet sport. *Human Movement Science*, 6, 283-319.

Amtmann, J.A. (2004). Self-reported training methods of mixed martial artists at a regional reality fighting event. *The Journal of Strength and Conditioning Research*, 18, 194-196.

Asia, A.A., Warkar, A.B. (2013). Auditory and visual reaction time in taekwondo players. *International Journal of Recent Trends in Science and Technology*, 8, 176-7.

Atan, T., & İmamoğlu, O. (2005). Competition analysis of world greco-roman and world free-style wrestling championships. *International Journal of Performance Analysis in Sport*, 5(1).

Avakian, S.P., Miarka, B., & Achour, A.J. (2017). Análise de frequência das ações técnico-táticas competitivas no taekwondo: uma revisão. *Revista de Artes Marciales Asiáticas*, 11(2), 83-98.

Araújo D. (Ed.). (2005). O contexto da decisão – A acção táctica no desporto. Lisboa: Visão e Contextos, Lda, 37-60.

Araujo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise*, 7(6), 653-76.

Badilin, A. (2014). Training process management based on a complex statistical estimation of curlers competitive activity. VIII International Scientific and Practical Conference of Students and Young Scientists. *Modern University Sport Science*. The Lesgaff National State University of Physical Education, Sport and Health, Saint Petersburg.

Barreto, H. (2001). Ensino do basquetebol no ambiente de jogo. In: Tavares, F., Janeira, M.A., Graça, A., Pinto, D., & Brandão, E. (Eds.), *Tendências actuais da investigação em basquetebol*. Porto, FCDEF-UP, 195-202.

Barna, T. (2013). Elite wrestlers orientation to tactical information. *International Journal of Wrestling Science*, 3(1), 10-16.

Bayer, C. (1974). *La pratique du hand-ball et son approche psycho-social*. Librairie J. Vrin, Paris.

Bocioaca, L. (2014). Technical and tactical optimization factors in judo. *Procedia - Social and Behavioral Sciences*, 389-94.

Boguszewski, D. (2014a). Dynamics of judo contests performed by top world judokas in the years 2008-2012. *Journal of Combat Sports and Martial Arts*, 1(2), 31-5.

Boguszewski, D. (2014b). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-6.

Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sports and Martial Arts*, 1(2), 67-72.

Boguszewski, D., & Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). *Archives of Budo*, 2, 40-4.

Bolotin, A., & Bakayev, V. (2018). Pedagogical practice for development of coordination potential of MMA fighters and estimation of its efficiency. *Journal of Human Sport and Exercise*, 13(1), 72-88. doi:<https://doi.org/10.14198/jhse.2018.131.08>

Borysiuk, Z. (2008). Psychomotor reactions in fencing dependence of stimuli type. *Revista Brasileira de Cineantropometria e Desempenho Humano*, 10(3), 223-29.

Cappai, I., Pierantozzi, E., Tam, E., Tocco, F., Angius, L., Milia, R., Squatrito, S., Concu, A., & Crisafulli, A. (2012). Physiological responses and match analysis of Muay Thai fighting. *International Journal of Performance Analysis in Sport*, 12(3), 507-516.

Castelo, J., Barreto, H., Alves, F., Santos, P.M., Carvalho, J., & Vieira, J. (1996). *Metodologia do treino desportivo* (1st ed). Lisboa: Universidade Técnica de Lisboa FMH.

Chaabène, H., Franchini, E., Miarka, B., Selmi, M.A., Mkaouer, B., & Chamari, K. (2014). Time-motion analysis and physiological responses to karate official combat sessions: is there a difference between winners and defeated karatekas? *International Journal of Sports Physiology and Performance*, 9, 302-308.

Chen, W.Y., Wu, S.K., Song, T.F., Chou, K.M., Wang, K.Y., Chang, Y.C., & Goodbourn, P.T. (2017). Perceptual and motor performance of combat-sport athletes differs according to specific demands of the discipline. *Perceptual and Motor Skills*, 124(1), 293-313. doi:[10.1177/0031512516681342](https://doi.org/10.1177/0031512516681342)

Chernozub, A., Korobeynikov, G., Mytskan, B., Korobeinikova, L., & Cynarski, W.J. (2018). Modelling mixed martial arts power training needs depending on the predominance of the strike or wrestling fighting style. *Journal of Martial Arts Anthropology*, 18(3), 28-36.

Cipriano, N. (1993). A technical-tactical analysis of freestyle wrestling. *Journal of Strength & Conditioning Research*, 7(3), 133-140.

Clausewitz, C. (2005). Da guerra e arte da estratégia. Tahyu.

Cular, K.D., & Tomljanovic, M. (2011). The differences between medalists and non-medalists at the 2008 Olympic games taekwondo tournament. *Human Movement*, 12(2), 165-170.

Davis, P., Wittekind, A., & Beneke, R. (2013). Amateur boxing: activity profile of winners and losers. *International Journal of Sports Physiology and Performance*, 8(1), 84-91.

Dal Bello, F., Brito, C.J., Amtmann, J., & Miarka, B. (2019). Ending MMA combat, specific grappling techniques according to the type of the outcome. *Journal of Human Kinetics*, 67(1), 271-280.

Dan Pankration Committee of Russia, DPCR. (2020). Official site. Available from: <http://dancommittee.ru/>

De Dreu, C.K., Nijstad, B.A., Baas, M., Wolsink, I., & Roskes, M. (2012). Working memory benefits creative insight, musical improvisation, and original ideation through maintained task-focused attention. *Personality & social psychology bulletin*, 38(5), 656-669. <https://doi.org/10.1177/0146167211435795>

De la Fuente, A., & Castejón, F. (2016). An evaluation of categories for tactical actions: A preliminary study of combat analysis in taekwondo. *Cultura Ciencia Deporte*, 11(32), 157-170.

Del Vecchio, F., Hirata, S., & Franchini, E. (2011). A Review of time-motion analysis and combat development in mixed martial arts matches at regional level tournaments. *Perceptual and Motor Skills*, Missoula, 112(2), 639-648.

Del Vecchio, F.B., Silva, J.J.R., & Farias, C.B. (2015). Análise temporal de combates de Muay Thai de nível nacional: Efeitos da fase competitiva. *Revista de Artes Marciales Asiáticas*, 10(1), 34-41.

De Quel., O.M., & Bennett, S.J. (2019). Perceptual-cognitive expertise in combat sports: a narrative review and a model of perception-action. *Revista Internacional de Ciencias del Deporte*, 58(15), 323-338.

De Quel, O.M., Ignacio A., Izquierdo, M., & Ayán, C. (2019). Does physical fitness predict future karate success? A study in young female karatekas. *International Journal of Sports Physiology and Performance*, 15. 10.1123/ijsp.2019-0435.

Dos Santos, D. A., Miarka, B., Dal Bello, F., Queiroz, A., de Carvalho, P., Brito, C. J., & Beneke, R. (2019). 10 Years on time-motion and motor actions of paired mixed martial arts athletes. *International journal of sports physiology and performance*, 14(3), 399-402. <https://doi.org/10.1123/ijsp.2018-0566>

Duricek, M. (1985). Estructura de la estrategia y la táctica en los juegos deportivos. *El Entrenador Español (Fútbol)*, 26, 24-28.

El Ashker, S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing. *International Journal of Performance*, 1(2), 356-64.

Fajen, B.R., Rilley, M.A., & Turvey, M.T. (2008). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, 40, 79-107.

Fargas, I. (1990). *Taekwondo – Alta competición*. Barcelona: Total Press.

Faro, H.K., Fortes, L.S., & Machado, D.G. (2020). Dynamics of cognitive performance at rest and after exhaustive exercise in top-three world-ranked mixed martial arts athletes: a series of case studies. *Journal of Sports Medicine and Physical Fitness*, 60(4), 664-668.

Federação Portuguesa de Full Contact, FPFC. (2018a). História e desenvolvimento do full contact em Portugal. Available from: <http://www.angelfire.com/pq/fppff/ultimatefullcontact.htm>

Federação Portuguesa de Full Contact, FPFC. (2018b). Principais eventos realizados desde 1988. Available from: [http://www.angelfire.com/pq/fppff/past\\_events.htm](http://www.angelfire.com/pq/fppff/past_events.htm)

Federação Portuguesa de Full Contact, FPFC. (2018c). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available from: <http://www.angelfire.com/pq/fppff/description.htm>

Ferreira, A. (2002). Ensinar os Jovens a Jogar... a melhor solução para a aprendizagem da técnica e da tática. *Revista Treino Desportivo*.

Filho, R.A.F., & Maccariello, C. (2009). A preparação psicológica no esporte de alto nível. Sua importância no desempenho competitivo de lutadores de mixed martial arts (MMA). *Revista Digital efdeportes.com*, 129, 1-23.

Fontani, G., Lodi, L., Felici A., Migliorini, S., & Corradeschi, F. (2006). Attention in athletes of high and low experience engaged in different open skill sports. *Perceptual and Motor Skills*, 102, 791-805.

Forbes, K., & Kolliopoulos, A. (2004). Reactive motion for an animated boxer. *CSC2529: Character Animation Final Project*.

Franchini, E., & Del Vecchio, F. (2010). Judo and variability: Application to technical actions during the match. In: Warnick, J., Martin, W. (Eds.). *Advancements in the Scientific Study of Combative Sports*. Hauppauge: Nova Science, 1, 79-96.

Franchini, E., Matsushigue, K.A., Del Vecchio, F.B., & Artioli, G.G. (2011). Physiological profiles of elite judo athletes. *Sports Medicine*, 41(2), 147-166.

Franchini, E., Sterkowicz, S., Meira, C., Gomes, F., & Tani, G. (2008). Technical variation in a sample of high-level judo players. *Perceptual and Motor Skills*, Missoula, 106(3), 859-69.

Franchini, E., & Takito, M.Y. (2014). Olympic preparation in brazilian judo athletes: description and perceived relevance of training practices. *Journal of Strength and Condition Research*, 28(6), 1606–1612.

Gierczuk, D., & Bujak, Z. (2013). The analysis of coordination training means used in the training of wrestlers. *Journal of Combat Sports and Martial Arts*, Medsportpress; 1(2), Vol. 4, 19-23. doi: 10.5604/20815735.1072230.

Greco, P.J. (2006). Conhecimento tático-técnico: eixo pendular da ação tática (criativa) nos jogos esportivos coletivos. *Revista Brasileira de Educação Física e Esporte*, São Paulo, 20(5), 210-212.

Gréhaigne, J.F., & Godbout, P. (1995). Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest*, 47, 490-505.

Gréhaigne, J.E, Guillon, R. (1992) L'utilisation des jeux d'opposition à l'école. *Revue de l'Education Physique*, (32)2, 51-67.

Hao, Y.A. (2019). Brief discussion on counter attack tactics and application technique in the sanda competition. *Frontiers in Sport Research*, 1(2), 47-53.

Heller, J., Peric, T., Dlouhá, R., Kohlíková, E., Melichna, J., & Nováková, H. (1998). Physiological profiles of male and female Taekwondo (ITF) black belts. *Journal of Sports Sciences*, 16(3), 243-249.

Hristovski, R., Davids, K., Araújo, D., & Button, C. (2006). How boxers decide to punch a target: emergent behaviour in nonlinear dynamical movement systems. *Journal of sports science & medicine*, 5, 60-73.

Hristovski, R., Davids, K., Araújo, D., & Passos, P. (2011). Constraints-induced emergence of functional novelty in complex neurobiological systems: A basis for creativity in sport. *Nonlinear Dynamics, Psychology, and Life Sciences*, 15(2), 175-206.

Hucko, C. (1981). Desarrollo de la creatividad y capacidad de improvisación del futbolista. *El Entrenador*, 10, 58-60.

Hutchison, M.G., Lawrence, D.W., Cusimano, M.D., & Schweizer, T.A. (2014). Head trauma in mixed martial arts. *American Journal Sports Medicine*, 42(6), 1352.

Ito, K., Hirose, N., Nakamura, M., Maekawa, N., Tamura, M., & Hirotsu, N. (2013). The transformation of technical-tactical behaviors from hand techniques used in attacking below belt after the 2010 International Judo Federation rule revision. *Archives of Budo Science of Martial Arts*, 9, 1-6.

Ito, K., Hirose, N., Tamura, M., & Nakamura, M. (2015). Alterations in kumite techniques and the effects on Score rates following the 2013 International Judo Federation rule revision. *Archives of Budo Science of Martial Arts*, 11, 87-92.

James, L.P., Haff G.G., Kelly, V.G., & Beckman, E.M. (2016). Towards a determination of the physiological characteristics distinguishing successful mixed martial arts athletes: a systematic review of combat sport literature. *Sports Medicine*, 46 (10), 1525-1551. doi: 10.1007 / s40279-016-0493-1

James, L.P., Robertson, S., Haff, G.G., Beckman, E.M., & Kelly, V.G. (2017). Identifying the performance characteristics of a winning outcome in elite mixed martial arts competition. *Journal of Science and Medicine in Sport*, 20, 296-301.

Kalina, R.M. (2000). *Teoria sportów walki*. COS, Warszawa.

Kalina, R.M. (2002). Metoda pomiaru dynamiki walki w sportach walki. In: Ulatowski T, editor. *Zastosowanie metod naukowych na potrzeby sportu*. Warszawa: Biblioteka PTNKF, 245-56

Kassim, S.F., Suwarganda, E.K., & Nor, E.A. (2015). Successful tactics in taekwondo during Sukan Malaysia 2012. Asia Pacific Conference on Performance Analysis of Sport Langkawi, Malaysia 2014, 21-24. *Journal of Human Sport and Exercise*, 1988-5202.

Kazemi, M., Casella C, & Perri, G. (2009). 2004 Olympic Taekwondo Athletes profile. *The Journal of Canadian Chiropractic Association*, 53(2), 144-152.

Kazemi, M., Perri, G., & Soave, D. (2010). A profile of 2008 Olympic Taekwondo Competitors. *The Journal of Canadian Chiropractic Association*, 54(4), 243-249.

Keller, V.S., & Tyshler, D.A. (1972). *Trenirovka fekhthovalshchikov [Fencer training]*. Moscow: Physical Culture and Sports, p182.

Kim, Y.J. (2006). *Taekwondo competição – O manual dos campeões*. São Paulo: Editora do Brasil.

Kimmel, M., & Rogler, C.R. (2019). The anatomy of antagonistic coregulation: Emergent coordination, path dependency, and the interplay of biomechanic parameters in Aikido. *Human Movement Science*, 63, 231-253.

Kirk, C., Hurst, H., & Atkins, S. (2015). Comparison of the training loads of mixed martial arts techniques in isolated training and open sparring. *Journal of Combat*

Sports and Martial Arts. Medsportpress, 1(2), vol. 6, 15-20. doi: 10.5604/20815735.1174226.

Konzag, I. (1983). La Formazione tecnico-tattica nei giochi sportivi. *Rivista di Cultura Sportiva*, 2(2), 42-47.

Korcek, F. (1981). Novos conceitos no treino dos futebolistas. *Futebol em Revista*, 3(11), 41-8.

Koropanovski, N., Dopsaj, M., & Jovanović, S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biometricity*, 2(4), 241-51.

Koroponovski, N., & Jovanović, S. (2007). Model characteristics of combat at elite male karate competitors. *Serbian Journal of Sports Sciences*, 1(3), 97-115.

Kostrubiec, V., Zanone, P.G., Fuchs, A., & Kelso, J.A.S. (2012). Beyond the blank slate: Routes to learning new coordination patterns depend on the intrinsic dynamics of the learner: Experimental evidence and theoretical model. *Frontiers in Human Neuroscience*, 6, 1-14.

Krabben, K., Orth, D., & Van der Kamp, J. (2019). Combat as an interpersonal synergy: An ecological dynamics approach to combat sports. *Sports Medicine*, 49, 1825-1836. doi.org/10.1007/s40279-019-01173-y

Kruszewski, M., Kruszewski, A., Kuźmicki, S., Sklepiński, L., Kępa, G., & Landowski, K. (2016). Boxing techniques based on the analysis of boxing tournament finals during Olympic Games in London in 2012. *Journal of Combat Sports and Martial Arts*. Medsportpress, 1(2), Vol. 7, 61-66. doi: 10.5604/20815735.1224961.

Kruyning, E., & De Jong, M. (2014). *Mma, The essentials of Mixed Martial Arts*. Eerste editie Edition.

Lee, L. (1975). *Tao of jeet kune do by Bruce Lee (1st ed)*. CA: Ohara Publications, Inc.

Lima, C.O.V., Matias, C.J.A.S., & Greco, P.J. (2012). O conhecimento tático produto de métodos de ensino combinados e aplicados em sequências inversas no voleibol. *Revista Brasileira de Educação Física e Esporte*, São Paulo, 26(1), 129-147.

Liu, Y.T., Mayer-Kress, G., & Newell, K.M. (2006). Qualitative and quantitative change in the dynamics of motor learning. *Journal of Experimental Psychology: Human Perception and Performance*, 32(2), 380-393.

López-Gonzalez, D. (2011). Tactical means classification in freestyle and female wrestling. XIX FDD Educacion Fisica, Deportes y Ciencias Aplicadas, Sto. Domingo, DO.

López-González, D. (2014). Technical-tactical performance in greco-roman wrestling: analysis of 2013 Senior World Championships through multivariate analysis. *International Journal of Wrestling Science*, 4(1), 95-110.

López-González, D.E., & Miarka, B. (2013). Reliability of a new time-motion model based on technical-tactical interactions for wrestling combats. *International Journal of Wrestling Science*, 3, 21-34.

Lópes-Ros, V., Avelar, B. (2015). Revisão do modelo integrado técnico tático de ensino Compreensivo do Desporto – Uma proposta teórica. *Journal of Sport Pedagogy and Research*, 1(8), 22-29.

Mahlo, F. (1997). *Acto tático no jogo* (1st ed). Lisboa: Compendium.

Malkov, O.B., & Ramashov, A.A. (2019). Key differences in combat tactics, action triggers and self-commands in taekwondo and boxing. Available from: [www.teoriya.ru/ru/node/8619](http://www.teoriya.ru/ru/node/8619)

Marcovic, G., Vucetic, V., & Cardinale, M. (2008). Heart Rate and lactate responses to Taekwondo fight in elite women performers. *Biology of Sport*, 25(2), 93-99.

Marteniuk, R.G. (1976). *Information Processing in Motor Skills*. NY: Holt, Rinehart & Winston.

Matveev, L.P. (1991). *Fundamentos do treino desportivo*. 2<sup>a</sup> ed. Lisboa: Horizonte, 261-305.

McPherson SL. (1994). The development of sport expertise: mapping the tactical domain. *Quest*, 46, 223-40.

McRobert, A.P., Ward, P., Eccles, D.W., & Williams, A.M. (2011). The effect of manipulating context-specific information on perceptual–cognitive processes during a simulated anticipation task. *British Journal of Psychology*. doi: 10.1348/2044-8295.002013

Meinel, K. (1984). *Motricidade I: teoria da motricidade esportiva sob o aspecto pedagógico*. Rio de Janeiro: Livro Técnico.

Menescardi, C., Bermejo, J.L., Herrero, C., Estevan, I., Landeo, R., & Falcó, C. (2012). Diferencias técnico tácticas en taekwondistas universitarios según sexo y categoría de competición. *Revista de Artes Marciales Asiáticas*, 7(2), 1-11.

Menescardi, C., Falco, C., Estevan, I., Ros, C., Morales-Sánchez, V., & Hernández-Mendo, A. (2019). Is it possible to predict an athlete's behavior? The use of polar coordinates to identify key patterns in taekwondo. *Frontiers in Psychology*, 10, 1232

Menescardi, C., Falco, C., Hernández-Mendo, A., & Morales-Sánchez, V. (2020). Talent and creativity of taekwondoists winners of the 2016 Summer Olympics. *Sustainability*, 12, 4185. doi:10.3390/su12104185

Miarka, B. (2016). Demandas técnico-táticas e fisiológicas de combates da luta Olímpica. *Revista de Artes Marciales Asiáticas*, 11(1), 18-31. doi: 10.18002/rama.v11i1.3309

Miarka, B., Brito, C.J., Dal Bello, F., & Amtmann, J. (2017). Motor actions and spatiotemporal changes by weight divisions of mixed martial arts: Applications for training. *Human Movement Science*, 55, 73-80.

Miarka, B., Coswig, V., Brito J.C., Slimani, M., Amtmann, J., & Del Vecchio, F.B. (2016). Comparison of combat outcomes: technical and tactical analysis of female MMA, *International Journal of Performance Analysis in Sport*, 16(2), 539-552.

Miarka, B., Fukuda, D., Vecchio, F., & Franchini, E. (2016). Discriminant analysis of technical-tactical actions in high-level judo athletes. *International Journal of Performance Analysis in Sport*, 16, 30-39.

Miarka, B., Julio, U.F., Del Vecchio, F.B., Calmet, M., & Franchini, E. (2010). Técnica y táctica en judo: una revisión. *Revista de Artes Marciales Asiáticas*, 5(1), 91-112.

Miarka, B., Pérez, D.I.V., Aedo-Muñoz, E., da Costa, L.O.F., & Brito, C.J. (2020). Technical-tactical behaviors analysis of male and female judo cadets' combats. *Frontiers in Psychology*, 11, 1389.

Milazzo, N., Farrow, D., & Fournier, J.F. (2016). Effect of implicit perceptual-motor training on decision-making skills and underpinning gaze behavior in combat athletes. *Perceptual and Motor Skills*, 123(1), 300-23.

Molina, J., & Castarlenas, J. (2002). Bases para una propuesta para la enseñanza del judo en el contexto escolar. In Castarlenas, J. & Molina, J. (edi.). *El Judo en la educación física escolar*. Barcelona, Editorial Hispano-Europea, 29-44.

Mori, S., Ohtani, Y., & Imanaka, K. (2002). Reaction times and anticipatory skills of karate athletes. *Human Movement Science*, Amsterdam, 21(2), 213-30.

Moraru, A., Memmert, D., & Van der Kamp, J. (2016). Motor creativity: The roles of attention breadth and working memory in a divergent doing task. *Journal of Cognitive Psychology*, 28(7), 856-867.

North, J.S., Williams, A.M., Hodges, N.J., Ward, P., & Ericsson, K.A. (2009). Perceiving patterns in dynamic action sequences: Investigating the processes underpinning stimulus recognition and anticipation skill. *Applied Cognitive Psychology*, 23, 878-894.

Oliveira, J., & Tavares, F. (1996). *Estratégia e tática nos jogos desportivos coletivos*. Porto: Centro de Estudos dos Jogos Desportivos FCDEF-UP.

Orth, D., van der Kamp, J., Memmert, D., & Savelsbergh, G. (2017). Creative motor actions as emerging from movement variability. *Frontiers in Psychology*, 8, 1903.

Ottoboni, G., Russo, G., & Tessari, A. (2015). What boxing-related stimuli reveal about response behaviour. *Journal of Sports Sciences*, 33(10), 1019-1027. <https://doi.org/10.1080/02640414.2014.977939>.

Ouergui, I., Hssin, N., Franchini, E., Gmada, N., & Bouhlef, E. (2013). Technical and tactical analysis of high level kickboxing matches. *International Journal of Performance Analysis in Sport*, 13(2), 294-309.

Parlebas, P. (1981). *Contribution a un lexique commenté en science de l'action motrice*. Paris: INSEP Publications.

Petri, K., Bandow, N., Salb, S., & Witte, K. (2018). The influence of facial expressions on attack recognition and response behaviour in karate kumite. *European Journal of Sport Science*, 1-10. <https://doi.org/10.1080/17461391.2018.1536170>.

Pieter, W. (1991). Performance characteristics of elite Taekwondo athletes. *Korean Journal of Sport Science*, 3, 94-117.

Pinto, F.C.L. (2015). *Perceção sobre as competências do treinador de desportos de combate (Master's Thesis)*. Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Rink, J. (1985). *Teaching physical education for learning*. Times Mosby College Publishing, ST. Louis.

Robles, A., Robles, J., Giménez, F.J., & Abad, M.T. (2016). Validación de una entrevista para estudiar el proceso formativo de judokas de élite. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte*, 16(64), 723-738.

Rodríguez, A.R, Rodríguez J.R, Fuentes-Guerra F.J.G, & Robles, M.T.A. (2018). Importancia del entrenamiento técnico-táctico y de condición física en el proceso de formación los judokas olímpicos españoles. *Revista de Artes Marciales Asiáticas*, 13(2s), 1719-2018. doi: 10.18002/rama.v13i2s.5499

Roi, S.G., & Bianchedi, D. (2008). The science of fencing: implications for performance and injury prevention. *Sports Medicine*, 38, 465-81.

Romashov, A.A. (2019). Tactical features of using counter attack in professional boxing. *Uchenye zapiski universiteta imeni P.F. Lesgafta*, 3(169), 271-74.

Röthig, P. (1983). *Sportwissenschaftliches Lexikon*. Hofmann Verlag, Schorndorf.

Rosalie, S.M., & Muller, S. (2013). Timing of in situ visual information pick-up that differentiates expert and near-expert anticipation in a complex motor skill. *Quarterly Journal of Experimental Psychology*, 66(10), 1951-62.

Russo, G., & Ottoboni, G. (2019). The perceptual - Cognitive skills of combat sports athletes: A systematic review. *Psychology of Sport and Exercise*, 44, 60-78.

Sagnol, J.A., & Bisciotti, G.K. (1997). La scelta decisionale nel judo: aspetti psicofisiologici e biomeccanici. *Rivista SdS* anno XVI, 41, 97-103.

Sánchez-García, R., Villaroya-Gil, Á., & Elrio-López, A. (2015) Manipulating task constraints of situated normativity to study decision making in krav maga. *International Journal of Sport Psychology*, 46, 1-00.

Santos, V., Franchini, E., & Lima-Silva, A. (2011). Relationship between attack and skipping in taekwondo contests. *Journal of Strength and Conditioning Research*, Champaign, 25(6), 1743-51.

Sarmiento, P. (2005). A função pedagógica do treinador: Uma abordagem comportamental. *Treino Desportivo*, 6, 46-51.

Segedi, I., Sertić, H., Franjić, D., & Kuštro, N. (2014). Analysis of judo match for seniors. *Journal of Combat Sports and Martial Arts*, 2(2), Vol. 5, 57-61.

Sherdog. (2017). The global authority on mixed martial arts. Organizations: World Ultimate Full Contact. Available from: <https://www.sherdog.com/organizations/World-Ultimate-Full-Contact-955>

Shih, Y.L., & Lin, C.Y. (2016). The relationship between action anticipation and emotion recognition in athletes of open skill sports. *Cognitive Processing*, 17(3), 259-268. <https://doi.org/10.1007/s10339-016-0764-7>.

Silva, J.J.R., Del Vecchio, F.B., Picanço, L.M., Takito, M.Y., & Franchini, E. (2011). Time–motion analysis in Muay-Thai and kick-boxing amateur matches. *Journal of Human Sport & Exercise*. Faculty of Education. University of Alicante, 6(3), 1988-5202.

Silva., P., Garganta, J., Araújo, D., & Davis, K. (2013). Shared knowledge or shared affordances? Insights from an ecological dynamics approach to team coordination in sports. *Sports Medicine*, 43, 765-72.

Slimani, M., Chaabène, H., Davis, P., Franchini, E., Cheour, F., & Chamari, K. (2017). Performance aspects and physiological responses in male amateur boxing competitions: A brief review. *Journal of Strength and Conditioning Research*, 31(4), 1132-1141. doi: 10.1519/JSC.0000000000001643

Slimani, M., Chaabène, H., Miarka, B., & Chamari, K. (2016). The activity profile of elite Low-kick kickboxing competition. *International Journal of Sports Physiology and Performance*, Epub ahead of print.

Submission Fighting World Federation, ADCC (2020). Official site. Available from: <https://adcombat.com/adcc-rules-regulations/>

Thelen, E. (1995). Motor development: A new synthesis. *American Psychologist*, 50(2), 79-95.

Teodorescu, L. (1987). Orientações e tendências da teoria e metodologia de treino nos Jogos desportivos. *Futebol em revista*, 4, 23, 37:45.

Tod, D., Edwards, C., McGuigan, M., & Lovell, G. (2015). A Systematic review of the effect of cognitive strategies on strength performance. *Sports Medicine*, 45, 1589-1602.

Tornello, F., Capranica, L., Chiodo S, Minganti, C., & Tessitore, A. (2013). Time-motion analysis of youth Olympic Taekwondo combats. *Journal of Strength and Conditioning Research*, 27(1), 223-228.

Travassos, B. (2014). *A Tomada de decisão no futsal*. Lisboa, Prime Books.

Urquidez, B. (1981). *Training and fighting skills* (1st ed). CA: Unique Publications, Inc.

Veiga, R. (Realizador), & Companhia de Ideias (Produtor). (2009). Vale Tudo – As Opções de São Mateus: A história de um Campeonato do Mundo Muito Particular... [Documentário TV]. Lisboa: RTP. Available from: <http://www.rtp.pt/programa/tv/p25602>

Vences Brito, A., & Silva, C. (2011). Reaction time in karate athletes. *Journal of Martial Arts Anthropology*, 11(4), 35-9

Vidranski, T., Maškarin, F., & Jukić, J. (2015). Differences in technical and tactical indicators of attacks and counterattacks in elite male karate fighters. *Acta Kinesiologica*, 1 (9), 19-24.

Vilar, L., Araújo, D., Davids, K., & Button, C. (2012). The role of ecological dynamics in analysing performance in team sports. *Sports Med*, 42(1), 1-10.

Wallace, B. (1982). *Dynamic stretching & kicking* (1st ed). CA: Unique Publications, Inc.

Wąsik, J., Pieter, W., & Borysiuk, Z. (2014). The effect of offensive and defensive actions on taekwondo sparring. *Journal of Combat Sports and Martial Arts*, 5(2), 27-30.

Weineck, J. (2001). *Salud, Ejercicio y Deporte*. 1º Edição. Editorial Paidotribo.

Williams, A.M., Ford, P.R., Eccles, D.W., & Ward, P. (2011). Perceptual-cognitive expertise in sport and its acquisition Implications for applied cognitive psychology. *Applied Cognitive Psychology*. doi: 10.1002/acp.1710

Withagen, R., & Van der Kamp, J. (2018). An ecological approach to creativity in making. *New Ideas in Psychology*, 49, 1-6. <https://doi.org/10.1016/j.newideapsych.2017.11.002>.

World Boxing Council, WBC. (2020). Rules & regulations. Available from: <https://wbcboxing.com/en/wbc/rules>

World League Pankration, WLP. (2020). Official site. Available from: <https://sites.google.com/pankration.by/wlcp/home-page>

World Taekwondo, WTF. (2020). Rules and documents. Available from: <http://www.worldtaekwondo.org/rules/>

World Ultimate Full Contact, WUFC. (2018). World Rankings. Available from: <http://ultimatefullcontact.tripod.com/wufrankings.htm>

## **Chapter 2 – Review Study - Study 1**

Adam, M., Klimowicz, P., & Pujszo, R. (2016). Judoists' tactical and technical efficiency during the World Championships in 2014 and 2015. *Baltic Journal of Health and Physical Activity*, 8(2), 19-28.

Adam, M., Pujszo, R., Stanisław, K., Szymański, M., & Tabakov, S. (2015). MMA fighters' technical-tactical preparation – fight analysis: a case study. *Journal of Combat Sports and Martial Arts*, 6, 35-41. 10.5604/20815735.1174229.

Adam, M., Smaruj, M., & Tyszkowski, S. (2011). The diagnosis of the technical-tactical preparation of judo competitors during the world championships (2009-2010) in the light of new judo sport rules. *Archives of Budo Science of Martial Arts*, 7:5-8.

Amtmann, J.A. (2004). Self-reported training methods of mixed martial artists at a regional reality fighting event. *The Journal of Strength and Conditioning Research*, 18, 194-196.

Amtmann, J.A., Amtmann, K.A., & Spath, W.K. (2008). Lactate and rate of perceived exertion responses of athletes training for and competing in a mixed martial arts event. *Journal of Strength and Conditioning Research*, 22, 645-647.

Antonietto, N.R., Dal Bello, F., Carrenho A.C.Q, Carvalho, P.H.B., Brito, C.J., Amtmann, J. & Miarka, B. (2019). Suggestions for professional mixed martial arts training with pacing strategy and technical-tactical actions by rounds. *Journal of Strength and Conditioning Research*, 23. doi: 10.1519/JSC.0000000000003018

Avakian, S.P., Miarka, B., & Achour, A.J. (2017). Análise de frequência das ações técnico-táticas competitivas no taekwondo: uma revisão. *Revista de Artes Marciales Asiáticas*, 11(2), 83-98.

Barna, T. (2013). Elite wrestlers' orientation to tactical information. *International Journal of Wrestling Science*, 3(1), 10-16.

Boguszewski, D. (2014). Dynamics of judo contests performed by top world judokas in the years 2008-2012. *Journal of Combat Sports and Martial Arts*, 1(2), 31-5.

Bolotin, A., & Bakayev, V. (2018). Pedagogical practice for development of coordination potential of MMA fighters and estimation of its efficiency. *Journal of Human Sport & Exercise*, 13(1), 72-88.

Castelo, J., Barreto, H., Alves, F., Santos, P.M., Carvalho, J., & Vieira, J. (1996). *Metodologia do treino desportivo* (1st ed). Lisboa: Universidade Técnica de Lisboa FMH.

Chen, W.Y., Wu, S.K., Song, T.F., Chou, K.M., Wang, K.Y., Chang, Y.C., & Goodbourn, P.T. (2017). Perceptual and motor performance of combat-sport athletes differs according to specific demands of the discipline. *Perceptual and Motor Skills*, 124(1), 293-313. doi:10.1177/0031512516681342

Chernozub, A., Korobeynikov, G., Bogdan., M., & Korobeinikova, L. (2018). Modelling mixed martial arts power training needs depending on the predominance of the strike or wrestling fighting style. *Journal of Martial Arts Anthropology*, 18(3), 28-36.

Coswig, V.S., de Paula, S.R., & Del Vecchio, F.B. (2016). Time-motion and biological responses in simulated mixed martial arts sparring matches. *Journal of Strength and Conditioning Research*, 30, 2156-2163.

Coswig, V.S., Hideyoshi, D.F., De Paula, S.R., & Del Vecchio, F.B. (2016). Biochemical differences between official and simulated mixed martial arts (MMA) matches. *Asian Journal of Sports Medicine*, 7(2), 30950.

Dal Bello, F., Brito, C.J., Amtmann, J., & Miarka, B. (2019). Ending MMA combat, specific grappling techniques according to the type of the outcome. *Journal of Human Kinetics*, 67, 271-280.

De la Fuente, A., & Castejón, F.J. (2016). An evaluation of categories for tactical actions: a preliminary study of combat analysis in taekwondo. *Cultura, ciencia y deporte*, 11(32), 157-70.

Del Vecchio, F.B., Hirata, S., & Franchini, E. (2011). A review of time-motion analysis and combat development in mixed martial arts matches at regional level tournaments. *Perceptual and Motor Skills*, 112(2), 112-639.

de Quel, O.M., & Bennett, S.J. (2019). Perceptual-cognitive expertise in combat sports: a narrative review and a model of perception-action. *Revista Internacional de Ciencias del Deporte*, 58(15), 323-338.

Federação Portuguesa de Full Contact, FPPFC. (2018b). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available from: <http://www.angelfire.com/pq/fppff/description.htm>

Federação Portuguesa de Full Contact, FPPFC. (2018a). História e desenvolvimento do full contact em Portugal. Available from: <http://www.angelfire.com/pq/fppff/ultimatefullcontact.htm>

Gibson, J.J. (1979). *The ecological approach to visual perception*. Mahwah, NJ: Lawrence Erlbaum Associates.

Gronek, P., Wielinski, D., & Gronek, J. (2015). Genetic and non-genetic determinants of aggression in combat sports. *Open Life Sciences*, 10(1), 7.

Ito, K., Hirose, N., Nakamura, M., Maekawa, N., Tamura, M., & Hirotsu, N. (2013). The transformation of technical-tactical behaviors from hand techniques used in attacking below belt after the 2010 International Judo Federation rule revision. *Archives of Budo Science of Martial Arts*, 9, 1-6.

Ito, K., Hirose, N., Tamura, M., & Nakamura, M. (2015). Alterations in kumite techniques and the effects on score rates following the 2013 International Judo Federation rule revision. *Archives of Budo Science of Martial Arts*, 11, 87-92.

James, L.P., Robertson, S., Haff, G.G., Beckman, E, M., & Kelly, V.G. (2017). Identifying the performance characteristics of a winning outcome in elite mixed martial arts competition. *Journal of Science and Medicine in Sport*, 20, 296-301.

Kalina, R.M.; Kulesza, A.; Mysłowski, B.; Wołkowicz, B.; Jagiełło, W.; Gabryś, T.; & Chodała, A. (2004). Dynamics of judo, boxing and taekwondo contests performed by finalists of Olympic Games in Sydney. In *Sport Training in Interdisciplinary Scientific Researches*; Szopa, J., Gabryś, T., Eds.; Publisher: Częstochowa University of Technology, Poland, 326-331.

Karpman, S., Reid, P., Phillips, L., Qin, Z., & Gross, D.P.(2016). Combative sports injuries: An Edmonton retrospective. *Clinical Journal of Sport Medicine*, 26(4), 332-334.

Kirk, C., Hurst, H.T., & Atkins, S. (2015). Measuring the workload of mixed martial arts using accelerometry, time motion analysis and lactate. *International Journal of Performance Analysis in Sport*, 15(1), 359-370.

Krabben, K., Orth, D., & van der Kamp, J. (2019). Combat as an interpersonal synergy: An ecological dynamics approach to combat sports. *Sports Medicine*, 49, 1825-1836.

Kruyning, E., & De Jong, M. (2014). *Mma, the essentials of mixed martial arts*. Lulu Press.1.

López-González, D. (2014). Technical-tactical performance in greco-roman wrestling: analysis of 2013 Senior World Championships through multivariate analysis. *International Journal of Wrestling Science* 4(1), 95-110.

López-González, D.E., & Miarka, B. (2013). Reliability of a new time-motion model based on technical-tactical interactions for Wrestling Combats. *International Journal of Wrestling Science* 3, 21-34.

Mahlo, F. (1997). *Acto Tático no jogo*. 1st ed. Lisboa: Compendium.

Maszczyk, A., Gołaś, A., Pietraszewski, P., Kowalczyk, M., Ciężczyk, P., Kochanowicz, A., Smółka, W., & Zając, A. (2018). Neurofeedback for the enhancement of dynamic balance of judokas. *Biology of Sport*, 35(1), 99.

Menescardi, C., Falco, C., Hernández-Mendo, A., & Morales-Sánchez, V. (2020). Talent and creativity of taekwondoists winners of the 2016 Summer Olympics. *Sustainability*, 12, 41-85.

Miarka, B. (2016). Demandas técnico-táticas e fisiológicas de combates da luta olímpica. *Revista de Artes Marciales Asiáticas*, 11(1), 18-31.

Miarka, B., Brito, C.J., & Amtmann, J. (2017). Performance probabilities and outcome effects in technical–tactical factors with bout phase changes of mixed martial arts. *International Journal of Performance Analysis in Sport*, 17, 510.

Miarka, B., Brito, C.J., Dal Bello, F., & Amtmann, J. (2017). Motor actions and spatiotemporal changes by weight divisions of mixed martial arts: Applications for training. *Human Movement Science*, 55, 73-80.

Miarka, B., Coswig, V., Brito, J.C., Slimani, M., Amtmann, J., & Del Vecchio, F.B. (2016). Comparison of combat outcomes: technical and tactical analysis of female MMA. *International Journal of Performance Analysis in Sport*, 16(2), 539-552.

Miarka, B., Cury, R., Julianetti, R., & Battazza, R. (2014). A comparison of time-motion and technical-tactical variables between age groups of female judo matches. *Journal of Sports Sciences*, 32(16), 1529-1538.

Miarka, B., Julio, U.F., Del Vecchio, F.B., Calmet, M., & Franchini, E. (2010). Técnica y táctica en judo: una revisión. *Revista de Artes Marciales Asiáticas*, 5(1), 91-112.

Miarka, B., Vecchio, F.B., Camey, S., & Amtmann, J.A. (2016). Comparisons: Technical-tactical and time-motion analysis of mixed martial arts by outcomes. *Journal of Strength and Conditioning Research*, 30(7), 1975-1984.

Pinto, F.C.L. (2015). Perceção sobre as competências do treinador de desportos de combate (Master's Thesis). Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Santos, V.G., Franchini, E., & Lima-Silva, A.E. (2011). Relationship between attack and skipping in Taekwondo contests. *Journal of Strength and Conditioning Research*, 25(6), 1743-1751.

Santos, D.A.D., Miarka, B., Dal Bello, F., Queiroz, A.C.C., Carvalho, H.B., Brito, C.J., & Beneke, R. (2018). 10-Years on time-motion and motor actions of paired mixed martial arts athletes. *International Journal of Sports Physiology and Performance*, 30, 1-13.

Slimani, M., Davis, P., Franchini, E., & Moalla, W. (2017). Rating of perceived exertion for quantification of training and combat loads during combat sport-specific activities: A short review. *Journal of Strength and Conditioning Research*, 31(1), 2889-2902.

Russo, G., & Ottoboni, G. (2019). The perceptual – cognitive skills of combat sports athletes: A systematic review. *Psychology of Sport and Exercise*, 44, 60-78.

Tabben, M., Miarka, B., Chamari, K., & Beneke, R. (2018). Decisive moment: A metric to determine success in elite karate bouts. *International Journal of Sports Physiology and Performance*, 1, 13(8), 1000-1004. doi: 10.1123/ijsp.2017-0526.

## **Chapter 3. Observational Studies - Study 2**

Adam, M., Pujszo, R., Stanislaw, K., & Szymanski, M. (2015). MMA fighters' technical-tactical preparation - fight analysis: a case study. *Journal of Combat Sports and Martial Arts*, 6(2), 35-41.

Araújo, D. (2005). O contexto da decisão – A acção táctica no desporto. (Ed.). Lisboa: Visão e Contextos, Lda, 37-60.

Araújo, D. (2006). Tomada de decisão no desporto. Cruz Quebrada: FMH Edições.

Araújo, D., & Davids, K. (2011). What exactly is acquired during skill acquisition. *Journal of Consciousness Studies*, 18(3-4), 7-23.

- Araujo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise*, 7(6), 653-76.
- Bocioaca, L. (2014). Technical and tactical optimization factors in judo. *Procedia - Social and Behavioral Sciences*, 389-94.
- Boguszewski, D. (2014a). Dynamics of judo contests performed by top world judokas in the years 2008-2012. *Journal of Combat Sports and Martial Arts*, 1(2), 5,31-5.
- Boguszewski, D. (2014b). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-6.
- Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sports and Martial Arts*, 1(2), 7, 67-72.
- Boguszewski, D., & Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). *Archives of Budo*, 2, 40-4.
- Castelo, J., Barreto, H., Alves, F., Santos, P.M., Carvalho, J., & Vieira, J. (1996). *Metodologia do treino desportivo* (1st ed). Lisboa: Universidade Técnica de Lisboa FMH.
- Cohen, L., & Holliday, M. (1982). *Statistics for social sciences*. London: Harper & Row.
- Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How small-sided and conditioned games enhance acquisition of movement and decision-making skills. *Exercise and Sport Sciences Reviews*, 41(3).
- De la Fuente, A., & Castejón, F.J. (2016). An evaluation of categories for tactical actions: a preliminary study of combat analysis in taekwondo. *Cultura, ciencia y deporte*, 11(32), 157-70.
- El Ashker S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing. *International Journal of Performance Analysis in Sport*, 11(2), 356-64.

Fajen, B.R., & Riley, M.A., Turvey MT. (2008). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, 40, 79-107.

Gréhaigne, J.F., & Godbout, P. (1995). Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest*, 47, 490-505.

Hristovski, R., Davids, K., Araújo, D., & Button, C. (2006). How boxers decide to punch a target: emergent behaviour in nonlinear dynamical movement systems. *Journal of Sports Science and Medicine*, 5, 60-73.

Kalina, R.M. (2002). Metoda pomiaru dynamiki walki w sportach walki. In: Ulatowski T, editor. *Zastosowanie metod naukowych na potrzeby sportu*. Warszawa: Biblioteka PTNKF, 245-56.

Kalina, R.M., Kulesza, A., Mysłowski, B., Wołkowicz, B., Jagiełło, W., Gabryś, T., & Chodała, A. (2004). Dynamics of judo, boxing and taekwondo contests performed by finalists of Olympic Games in Sydney. In *Sport Training in Interdisciplinary Scientific Researches*; Szopa, J., Gabryś, T., Eds.; Publisher: Częstochowa University of Technology, Poland, 326-331.

Keller, V.S., & Tyshler, D.A. (1972). *Trenirovka fekhtovalshchikov [Fencer training]*. Moscow: Physical Culture and Sports, 182.

Koropanovski, N., Dopsaj, M., & Jovanović, S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biomotricity*, 2(4), 241-51.

Koroponovski, N., & Jovanović, S. (2007). Model characteristics of combat at elite male karate competitions. *Serbian Journal of Sports*, 1(3), 97-115.

Kruszewski, M., Kruszewski, A., Kuźmicki, S., Sklepiński, Ł., Kępa, G., & Landowski, K. (2016). Boxing techniques based on the analysis of boxing tournament finals during Olympic Games in London in 2012. *Journal of Combat Sports and Martial Arts*, 1(2), 7, 61-66.

Lee L. (1975). *Tao of jeet kune do by Bruce Lee*. 1st ed. CA: Ohara Publications, Inc.

Mahlo, F. (1997). *Acto Tático no jogo*. 1st ed. Lisboa: Compendium.

Malkov, O.B., & Ramashov, A.A. (2019). Key differences in combat tactics, action triggers and self-commands in taekwondo and boxing. [cited 2020 Jan 24]. Available from: [www.teoriya.ru/ru/node/8619](http://www.teoriya.ru/ru/node/8619)

McPherson, S.L. (1994). The development of sport expertise: mapping the tactical domain. *Quest*, 46, 223-40.

Miarka, B., Fukuda, D.H., Del Vecchio, F., & Franchini, E. (2016). Discriminant analysis of technical-tactical actions in high-level judo athletes. *International Journal of Performance Analysis in Sport*, 16, 30-9.

Milazzo, N., Farrow, D., & Fournier, J.F. (2016). Effect of implicit perceptual-motor training on decision-making skills and underpinning gaze behavior in combat athletes. *Perceptual and Motor Skills*, 123(1), 300-23.

Peixoto, C. (1997). *Sistemática das actividades desportivas - modelos e sistemas de análise do desempenho desportivo*. Lisboa: Edições FMH.

Pinto, F.C.L. (2015). *Perceção sobre as competências do treinador de desportos de combate (Master's Thesis)*. Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Pityni, M., Okopnyy, A., Tyravskys, O., Hutsul, N., & Ilnytskyi, I. (2017). Dynamic of indexes of technical and tactical actions of qualified kickboxer individual fighting style. *Journal of Physical Education and Sport*, 17(3), 1024-30.

Sánchez-García, R., Villaroya-Gil, Á., & Elrío-López, A. (2015). Manipulating task constraints of situated normativity to study decision making in krav maga. *International Journal of Sport Psychology*, 46, 1-00.

Segedi, I., Sertić, H., Franjić, D., Kustro, N., & Rozac, D. (2014). Analysis of judo match for seniors. *Journal of Combat Sports and Martial Arts*, 2(2), 5:57-61.

Shih, Y.L., & Lin, C.Y. (2016). The relationship between action anticipation and emotion recognition in athletes of open skill sports. *Cognitive Processing*, 17(3), 259-68.

Silva, J.J.R., Del Vecchio, F., Picanço, L.M., & Takito, M.Y. (2011). Time–motion analysis in Muay-Thai and kick-boxing amateur matches. *Journal of Human Sport & Exercise*. Faculty of Education. University of Alicante, 6(3), 1988-5202.

Silva, P., Garganta, J., Araújo D., Davis, K., & Aguiar, P. (2013). Shared knowledge or shared affordances? Insights from an ecological dynamics approach to team coordination in sports. *Sports Medicine*, 43, 765-72.

Silva, P., Travassos, B., Vilar, L., Aguiar, P., Davis, K., Araújo, D., & Garganta, J. (2014). Numerical relations and skill level constrain coadaptive behaviors of agents in sports teams. *PLoS One*, 9, 107112.

Sterkowicz-Przybycień, K., Miarka, B., & Fukuda, D. (2017). Sex and weight category differences in time–motion analysis of elite judo athletes: implications for assessment and training. *Journal of Strength and Conditioning Research*, 31(3), 817-25.

Travassos, B., Duarte, R., Vilar, L., Davis, K., & Araújo, D. (2012). Practice task design in team sports: Representativeness enhanced by increasing opportunities for action. *Journal of Sports Sciences*. <http://dx.doi.org/10.1080/02640414.2012.712716>

Travassos, B., Gonçalves, B., Marcelino, R., Monteiro, R., & Sampaio, J. (2014). How perceiving additional targets modifies teams' tactical behavior during football small-sided games. *Human Movement Science*, 38, 241-50.

Urquidez, B. (1981). *Training and fighting skills*. 1st ed. CA: Unique Publications, Inc.

Vidranski, T., Maškarin, F., & Jukić, J. (2015). Differences in technical and tactical indicators of attacks and counterattacks in elite male karate fighters. *Acta Kinesiologicaogica*, 1(9), 19-24.

Vilar, L., Araújo, D., Davis, K., & Button, C. (2012). The role of ecological dynamics in analysing performance in team sports. *Sports Medicine*, 42(1), 1-10.

Wallace B. (1982). *Dynamic stretching & kicking*. 1st ed. CA: Unique Publications, Inc.

Wąsik, J., Pieter, W., & Borysiuk Z. (2014). The effect of offensive and defensive actions on taekwondo sparring. *Journal of Combat Sports and Martial Arts*, 5(2), 27-30.

Wąsik, J., & Ślęzak, A. (2004). The evaluation of the efficiency of various techniques in taekwon-do female sparring over 70 kg. *Sport Training in Interdisciplinary Science research*, Częstochowa, 320-25.

Williams, A.M., Ford, P.R., Eccles, D.W., & Ward, P. (2011). Perceptual-cognitive expertise in sport and its acquisition: implications for applied cognitive psychology. *Applied Cognitive Psychology*, 25, 432-42.

World Ultimate Full Contact, WUFC. (2018a). World Rankings. Available from: <http://ultimatefullcontact.tripod.com/wuferankings.htm>

World Ultimate Full Contact, WUFC. (2018b). World Championships: Portugal Results. Available from: <http://ultimatefullcontact.tripod.com/wufcfighters.htm>

### **Chapter 3. Study 3**

Asia, A.A., & Warkar, A.B. (2013). Auditory and visual reaction time in taekwondo players. *International Journal of Recent Trends in Science and Technology*, 8, 176-7.

Ayu, F., Suwarganda, E., & Mohd, Nor E. (2015). Successful tactics in taekwondo during Sukan Malaysia 2012. Asia Pacific Conference on Performance Analysis of Sport 2124 April 2014. Langkawi, Malaysia. *Journal of Human Sport & Exercise*, ISSN, 1988-5202.

Bayer, C. (1974). *La pratique du hand-ball et son approche psycho-social*. Librairie J. Vrin, Paris.

Bocioaca, L. (2014). Technical and tactical optimization factors in judo. *Procedia - Social and Behavioral Sciences*, 389-94.

Boguszewski, D. (2011). Defensive actions of world top judoists. *J Hum Kinet*, 27, 113-23.

Boguszewski, D. (2014). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-6.

Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sports and Martial Arts*, 7, 67-72.

Boguszewski, D., & Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). *Archives of Budo*, 2, 40-4.

Borysiuk, Z. (2008). Psychomotor reactions in fencing dependence of stimuli type. *Revista Brasileira de Cineantropometria e Desempenho Humano*, 10(3), 223-29.

Castelo, J., Barreto, H., Alves, F., Santos, P.M., Carvalho, J., & Vieira, J. (1996). *Metodologia do treino desportivo* (1st ed). Lisboa: Universidade Técnica de Lisboa FMH.

Cohen, L., & Holliday, M. (1982). *Statistics for social sciences*. London: Harper & Row.

David, E., & López, G. (2014). Technical-tactical performance in greco-roman wrestling: analysis of 2013 senior world championships through multivariate analysis. *Int J Wrestl Sci*, 4(1), 95-130.

El Ashker, S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing. *International Journal of Performance*, 11(2), 356-64.

Fajen, B.R., Rille, M.A., & Turvey, M.T. (2008). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, 40, 79-107.

Federação Portuguesa de Full Contact, FPFC. (2018). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available from: <http://www.angelfire.com/pq/fppff/description.htm>

Fontani, G., Lodi, L., Felici, A., Migliorini, S., & Corradeschi, F. (2006). Attention in athletes of high and low experience engaged in different open skill sports. *Perceptual and Motor Skills*, 102(3), 791-805.

Forbes, K., & Kolliopoulos, A. (2004). Reactive motion for an animated boxer. CSC2529: Character Animation Final Project.

González, L., & Miarka, B. (2013). Reliability of a new time-motion model based on technical tactical interactions for wrestling combats. *Int. J. Wrestl. Sci*, 3(1), 21-6.

Hao, Y.A. (2019). Brief discussion on counter attack tactics and application technique in the Sanda competition. *Frontiers in Sport Research*, 1(2), 47-53.

Hristovski, R., Davids, K., Araújo, D., & Button, C. (2006). How boxers decide to punch a target: Emergent behaviour in nonlinear dynamical movement systems. *J Sport Sci Med*, 5, 60-73.

Hucko, C. (1981). Desarrollo de la creatividad y capacidad de improvisación del futbolista. *El Entrenador*, 10, 58-60.

Kalina, R.M. (2002). Metoda pomiaru dynamiki walki w sportach walki. In: Ulatowski T. editor, *Zastosowanie metod naukowych na potrzeby sportu*. Warszawa: Biblioteka PTNKF, 245-56.

Kalina, R.M., Kulesza, A., Mysłowski, B., Wołkowicz, B., Jagiełło, W., Gabryś, T., & Chodała, A. (2004). Dynamics of judo, boxing and taekwondo contests performed by finalists of Olympic Games in Sydney. In *Sport Training in Interdisciplinary Scientific Researches*; Szopa, J., Gabryś, T., Eds.; Publisher: Częstochowa University of Technology, Poland, 326-331.

Korcek, F. (1981). Novos conceitos no treino dos futebolistas. *Futebol em Revista*, 3(11), 41-8.

Malkov, O.B., & Romashov, A.A. (2018). Fundamental differences in the tactics of fighting for imprecise and starting signals in boxing and taekwondo. *Theory Pract Phys Cult*, 7, 56-8.

Meinel, K. (1984). *Teoria da motricidade esportiva sob o aspecto pedagógico*. Rio de Janeiro: Livro Técnico, Motricidade I.

Miarka, B., Julio, U.F., Del Vecchio, F.B., Calmet, M., & Franchini, E. (2010). Técnica y táctica en judo: una revisión. *Revista de Artes Marciales Asiáticas*, 5(1), 91-112.

Mori, S., Ohtani, Y., & Imanaka K. (2002). Reaction times and anticipatory skills of karate athletes. *Human Movement Science*, 21, 213-30.

Ottoboni, G., Russo, G., Tessari, A., & Francis, T. (2015). What boxing-related stimuli reveal about response behaviour. *Journal of Sports Sciences*, 33(10), 1019-27.

Parlebas P. (1981). *Contribution a un lexique commenté en science de l'action motrice*. Paris: INSEP Publications.

Pinto, F.C.L. (2015). *Perceção sobre as competências do treinador de desportos de combate (Master's Thesis)*. Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Roi, S.G., & Bianchedi, D. (2008). The science of fencing: implications for performance and injury prevention. *Sports Medicine*, 38, 465-81.

Romashov, A.A. (2019). Tactical features of using counter attack in professional boxing. *Uchenye zapiski universiteta imeni P.F. Lesgafta*, 3(169), 271-74.

Romashov, A.A., Malkov, O.B., & Zvezdova, A.O. (2018). The problem of the effectiveness and the complexity of the use of side-by-side maneuvers to carry out a counter-attack in boxing, *Martial arts and martial arts: science, practice, education, Proceedings of the III All-Russian Scientific and Practical Conference with International Participation*, September 21; Moscow, 194-6.

Rosalie, S.M., & Muller, S. (2013). Timing of in situ visual information pick-up that differentiates expert and near-expert anticipation in a complex motor skill. *Journal of Experimental Psychology*, 66(10), 1951-62.

Sagnol, J.A., & Bisciotti, G.K. (1997). La scelta decisionale nel judo: aspetti psicofisiologici e biomeccanici. *Rivista SdS* anno XVI, 41, 97-103.

Shih, Y.L., & Lin, C.Y. (2016). The relationship between action anticipation and emotion recognition in athletes of open skill sports. *Cognitive Processing*, 17, 259-68.

Urquidez, B. (1981). *Training and fighting skills*. 1st ed. CA: Unique Publications, Inc.

Vences Brito, A., & Silva, C. (2011). Reaction time in karate athletes. *Journal of Martial Arts Anthropology*, 11(4), 35-9.

Vidranski, T., Maškarin, F., & Jukić, J. (2015). Differences in technical and tactical indicators of attacks and counterattacks in elite male karate fighters. *Acta Kinesiologicaogica*, 1(9), 19-24.

Wallace, B. (1982). *Dynamic stretching & kicking*. 1st ed. CA: Unique Publications, Inc.

World Ultimate Full Contact, WUFC. (2018a). World Rankings. Available from: <http://ultimatefullcontact.tripod.com/wufrankings.htm>

### **Chapter 3. Study 4**

Adam, M., Pujszo, R., Kuźmicki, S., & Szymański, M. (2015). MMA fighters' technical-tactical preparation – fight analysis: a case study. *Journal of Combat Sports and Martial Arts*, 1(2), Vol.6, 35-1.

Adam, M., & Sterkowicz-Przybycień, K. (2018). The efficiency of tactical and technical actions of the national teams of Japan and Russia at the World Championships in Judo (2013, 2014 and 2015). *Biomedical Human Kinetics*, 10(1), 45-52.

Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sport and Martial Arts*, 7:67-72.

Boguszewski, D. (2014a). Dynamics of judo contests performed by top world judokas in the years 2008-2012. *Journal of Combat Sports and Martial Arts*, 1(2), 31-35.

Boguszewski, D. (2006). Fight dynamics of the double Olympic Champion in judo (1988, 1992). *Journal of Human Kinetics*, 16, 97-106.

Boguszewski, D. (2014b). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-6.

Boguszewski, D., & Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European championships (Rotterdam 2005). *Archives of Budo* 2:40-44.

Branco, B., Massuca, L.M., Andreato, M.B., Monteiro, L., Miarka, B., Franchini, E. (2013). Association between the Rating Perceived Exertion, Heart Rate and Blood Lactate in Successive Judo Fights (Randori), *Asian Journal of Sports Medicine*, 4, 125-130.

Crossley, T. (2015). Performance profiling in professional mixed martial arts (MMA): comparing winning and losing performances. (Master's thesis). University of Chester, United Kingdom.

Cular, K.D., & Krstulovic, S. (2011). The differences between medalists and non-medalists at the 2008 Olympic games taekwondo tournament. *Human Movement*, 12(2), 165-70.

Davis, P., Benson, P.R., Waldock, R., & Connorton, A.J. (2016). Performance analysis of elite female amateur boxers and comparison with their male counterparts. *International Journal of Sports Physiology and Performance*, 11(1), 55-60. <https://doi.org/10.1123/ijsp.2014-0133>

Davis, P., Wittekind, A., & Beneke, R. (2013). Amateur boxing: Activity profile of winners and losers. *International Journal of Sports Physiology and Performance*, 8(1), 84-91. <https://doi.org/10.1123/ijsp.8.1.84>

Del Vecchio, FB., Hirata, S.M., & Franchini, E. (2011). A review of time-motion analysis and combat development in mixed martial arts matches at a regional level tournament. *Perceptual and Motor Skills*, 112(2), 639-48.

El Ashker, S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing, *International Journal of Performance Analysis in Sport* 2011; 11(2), 356-364.

Federação Portuguesa de Full Contact, FPFC. (2018a). História e desenvolvimento do full contact em Portugal. Available from: <http://www.angelfire.com/pq/fppff/ultimatefullcontact.htm>

Federação Portuguesa de Full Contact, FPFC. (2018b). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available from: <http://www.angelfire.com/pq/fppff/description.htm>

Forbes K., & Kolliopoulos, A. (2004). Reactive motion for an animated boxer. CSC2529: Character Animation Final Project, May 3.

James, L.P., Kelly, V.G. & Beckman, E.M. (2013). Periodization for mixed martial arts. *Strength & Conditioning Journal*, 35(6), 34-45.

Kalina, R.M. (2002). Metoda pomiaru dynamiki walki w sportach walki. In: Ulatowski T, editor. *Zastosowanie metod naukowych na potrzeby sportu*. Warszawa: Biblioteka PTNKF 2002; 245-56

Kassim, S.F., Suwarganda, E.K., & Nor EA. (2015). Successful tactics in taekwondo during Sukan Malaysia 2012. *Journal of Human Sport and Exercise*, 10(2), 1988-5202.

Kirk, C., Hurst, H., & Atkins, S. (2015). Measuring the workload of mixed martial arts using accelerometry, Time motion analysis and lactate. *International Journal of Performance Analysis in Sport*, 15(1), 359-70.

Korobeynikov, G., Shtanagey, D., Ieremenko, N., Aksiutin, V., Danko, T., Danko, G., Goletc, A., Korobeynikova, L., Maximovich, N.; Dudorva, L., & Kolumbert, A. (2020). Evaluation of the speed of a complex visual-motor response in highly skilled female boxers. *Journal of Physical Education and Sport*, 20(4), Art 235, 1734-1739. DOI:10.7752/jpes.2020.04235

Lee L. (1975). *Tao of jeet kune do* by Bruce Lee. 1st ed. CA: Ohara Publications, Inc.

Malkov, O.B., & Kalashnikov, M.Y. (2015). Tactical characteristics of alternative start when striking a blow and finishing attack in martial arts. *Theory and practice of physical culture*, 9, 75-77.

Malkov, O.B., Zvezdova A.O. (2018). Problem of effectiveness and difficulty of side maneuver in counter attack in boxing. *Martial arts and martial arts: science, practice, education*. Proc. III nat. res. practical Conference with international participation. Moscow, September 21, 194-196.

Marcon, G., Franchini, E., Jardim, J.R. & Barros Neto, T.L. (2010), Structural Analysis of Action and Time in Sports: Judo, *Journal of Quantitative Analysis in Sport*, 6, 1-13.

Miarka, B., Brito, J.C., & Amtmann, J. (2017). Performance probabilities and outcome effects in technical-tactical factor with bout phase changes of mixed martial arts. *International Journal of Performance Analysis in Sport*, 17(4), 510-20.

Miarka, B., Coswig, V., Brito, J.C. Slimani, M., Amtmann, J., & Del Vecchio, F.B. (2016). Comparison of combat outcomes: technical and tactical analysis of female MMA. *International Journal of Performance Analysis in Sport*, 16(2), 539-52.

Pinto F.C.L. (2015). Perceção sobre as competências do treinador de desportos de combate (Master's Thesis). Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Romashov, A.A. (2019). Tactical features of using counter attack in professional boxing. *Uchenye zapiski universiteta imeni P.F. Lesgafta*, 3(169), 271-74.

Slimani, M., Chaabène, H., Davis, P., Franchini, E., Cheour, F., & Chamari, K. (2017). Performance aspects and physiological responses in male amateur boxing competitions: A brief review. *Journal of Strength and Conditioning Research*, 31(4), 1132-1141. doi: 10.1519/JSC.0000000000001643

Urquidez, B. (1981). *Training and fighting skills*. 1st ed. CA: Unique Publications, Inc.

World Ultimate Full Contact, WUFC. (2018). World Rankings. Available from: <http://ultimatefullcontact.tripod.com/wufcrankings.htm>

## **Chapter 3. Study 5**

Adam, M., Pujszo, R., Kuźmicki, S., & Szymański, M. (2015). MMA fighters' technical-tactical preparation—Fight analysis: A case study. *Journal of Combat Sports and Martial Arts*, 6, 35-41.

Antoniettô, N.R., Bello, F.D., Carrenho Queiroz, A.C., Berbert de Carvalho, P.H., Brito, C.J., Amtmann, J., & Miarka, B. (2019). Suggestions for professional mixed martial arts

training with pacing strategy and technical-tactical actions by rounds. *Journal of Strength and Conditioning Research.*, doi:10.1519/JSC.0000000000003018.

Bledsoe, G.H., Hsu, E.B., Grabowski, J.G., Brill, J.D., & Li, G. (2006). Incidence of injury in professional mixed martial arts competitions. *Journal of Sports Science and Medicine*, 5, 136-142.

Boguszewski, D. (2014). Dynamics of judo contests performed by top world judokas in the years 2008–2012. *Journal of Combat Sports and Martial Arts*, 1, 31-35.

Boguszewski, D. (2014). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-106.

Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sports and Martial Arts*, 7, 67-72.

Boguszewski, D., Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). *Archives of Budo*, 2, 40-44.

Buse, G.J. (2006). No holds barred sport fighting: A 10-year review of mixed martial arts competition. *British Journal of Sports Medicine.*, 40, 169-172.

Chaabene, H., Franchini, E., Miarka, B., Selmi, M.A., Mkaouer, B., & Chamari, K. (2014). Time-motion analysis and physiological responses to karate official combat sessions: Is there a difference between winners and defeated karatekas? *Journal of Sports Physiology and Performance*, 9, 302-308.

Dal Bello, F., Brito, C.J., Amtmann, J., & Miarka, B. (2019). Ending MMA combat, specific grappling techniques according to the type of the outcome. *Journal of Human Kinetics*, 67, 271-280.

Del Vecchio, F.B., Hirata, S.M., & Franchini, E. (2011). A review of time-motion analysis and combat development in mixed martial arts matches at regional level tournaments. *Perceptual and Motor Skills*, 112, 639-648.

El Ashker, S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing. *International Journal of Performance Analysis in Sport*, 11, 356-364.

Federação Portuguesa de Full Contact, FPFC. (2018<sup>a</sup>). História e desenvolvimento do full contact em Portugal. Available online: <http://www.angelfire.com/pq/fppff/ultimatefullcontact.htm> (accessed on 11 August 2020).

Federação Portuguesa de Full Contact, FPFC. (2018b). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available online: <http://www.angelfire.com/pq/fppff/description.htm> (accessed on 21 October 2019).

Fightmatrix.com. Available online: <http://www.fightmatrix.com/mma-records-stats/mma-fight-outcomes-by-year/> (accessed on 11 August 2020).

Hackett, S.R., & Storey, J.D. (2017). Mixed membership martial arts: Data-driven analysis of winning martial arts styles. In *Proceedings of the Sloan Sports Conference*, Hynes Convention Center, 3-4 March, Boston, MA, USA.

Hutchison, M., Cusimano, M., Lawrence, D., & Singh, T. (2013). Comprehensive analysis of 'knockouts' in mixed martial arts (MMA). *British Journal of Sports Medicine*, 47, e1.

Hutchison, M.G., Lawrence, D.W., Cusimano, M.D., & Schweizer, T.A. (2014). Head trauma in mixed martial arts. *American Journal of Sports Medicine*, 42, 1352-1358.

James, L.P., Kelly, V.G., & Beckman, E.M. (2013). Periodization for mixed martial arts. *Strength and Conditioning Journal*, 35, 34-45.

James, L.P., Robertson, S., Haff, G.G., Beckman, E.M., & Kelly, V.G. (2017). Identifying the performance characteristics of a winning outcome in elite mixed martial arts competition. *Journal of Science and Medicine in Sport*, 20, 296-301.

Kalina, R.M. (2002). Metoda pomiaru dynamiki walki w sportach walki. In *Zastosowanie Metod Naukowych na Potrzeby Sportu*, Ulatowski, T., Ed., Biblioteka PTNKF: Warszawa, Poland, 245-256.

Kalina, R.M., Kulesza, A., Mysłowski, B., Wołkowicz, B., Jagiełło, W., Gabryś, T., & Chodała, A. (2004). Dynamics of judo, boxing and taekwondo contests performed by finalists of Olympic Games in Sydney. In *Sport Training in Interdisciplinary Scientific Researches*, Szopa, J., Gabryś, T., Eds., Publisher: Częstochowa University of Technology, Poland, pp. 326-331.

Kirk, C., Hurst, H.T., & Atkins, S. (2015). Measuring the workload of mixed martial arts using accelerometry, time motion analysis and lactate. *International Journal of Performance Analysis in Sport*, 15, 359-370.

Koropanovski, N., Dopsaj, M., & Jovanović, S. (2008). Characteristics of pointing actions of top male competitors in karate at world and European level. *Brazilian Journal of Biomechanics*, 2, 241-251.

Koropanovski, N., & Jovanović, S. (2007). Model characteristics of combat at elite male karate competitors. *Serbian Journal of Sports Sciences*, 1, 97-115.

Maszczyk, A., Golas, A., Pietraszewski, P., Kowalczyk, M., Cieszyk, P., Kochanowicz, A., Smólka, W., & Zajac, A. (2018). Neurofeedback for enhancement of dynamic balance of judokas. *Biology of Sport*, 35, 99-102.

Miarka, B., Coswig, V., Brito, J.C., Slimani, M., Amtmann, J., & Del Vecchio, F.B. (2016). Comparison of combat outcomes: Technical and tactical analysis of female MMA. *International Journal of Performance Analysis in Sport*, 16, 539-552.

Miarka, B., Dal Bello, F., Brito, C.J., Del Vecchio, F.B., Amtmann, J., & Chamari, K. (2019). A 12-Year cohort study of doc-stoppage in professional mixed martial arts. *Journal of Sports Physiology and Performance*, 14, 606-611.

Miarka, B., Vecchio, F.B., Camey, S., & Amtmann, J.A. (2016). Comparisons: Technical-tactical and time-motion analysis of mixed martial arts by outcomes. *Journal of Strength and Conditioning Research*, 30, 1975-1984.

Pinto, F.C.L. (2015). *Percepção sobre as competências do treinador de desportos de combate* (Master's Thesis), Instituto Politécnico da Guarda, Guarda, Portugal. Available online: <http://hdl.handle.net/10314/2279> (accessed on 11 August 2020).

Segedi, I., Sertic, H., Franjic, D., Kustro, N., & Rozac, D. (2014). Analysis of judo match for seniors. *Journal of Combat Sports and Martial Arts*, 2, 57-61.

Slimani, M., Chaabène, H., Davis, P., Franchini, E., Cheour, F., & Chamari, K. (2017). Performance aspects and physiological responses in male amateur boxing competitions: A brief review. *Journal of Strength and Conditioning Research*, 31, 1132-1141.

Wąsik, J., Pieter, W., & Borysiuk, Z. (2014). The effect of offensive and defensive actions on taekwondo sparring. *Journal of Combat Sports and Martial Arts*, 5, 27-30.

World Ultimate Full Contact, WUFC. (2018). World rankings. Available online: <http://ultimatefullcontact.tripod.com/wufcrankings.htm> (accessed on 21 October 2019).

## **Chapter 4, General Discussion**

Abernethy, B., & Russell, D.G. (1987). The relationship between expertise and visual search strategy in a racquet sport. *Human Movement Science*, 6, 283-319.

Adam, M., Pujszo, R., Stanisław, K., Szymański, M., & Tabakov, S. (2015). MMA fighters' technical-tactical preparation – fight analysis: a case study. *Journal of Combat Sports and Martial Arts*, 6, 35-41. 10.5604/20815735.1174229.

Adam, M., & Sterkowicz-Przybycień, K. (2018). The efficiency of tactical and technical actions of the national teams of Japan and Russia at the World Championships in Judo (2013, 2014 and 2015). *Biomedical Human Kinetics*, 10, 45.

Amtmann, J.A. (2004). Self-reported training methods of mixed martial artists at a regional reality fighting event. *The Journal of Strength and Conditioning Research*, 18, 194-196.

Antonietto, N.R., Bello, F.D., Carrenho Queiroz, A.C., Berbert de Carvalho, P.H., Brito, C.J., Amtmann, J., & Miarka, B. (2019). Suggestions for professional mixed martial arts training with pacing strategy and technical-tactical actions by rounds. *Journal of Strength and Conditioning Research*, 23, Epub ahead of print.

- Araújo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise*, 7(6), 653–676.
- Boguszewski, D. (2014a). Dynamics of judo contests performed by top world judokas in the years 2008-2012. *Journal of Combat Sports and Martial Arts*, 1(2), Vol.5, 31-35.
- Boguszewski, D. (2014b). Offensive activity as an element of the evaluation of struggle dynamics of judo contestants. *Archives of Budo*, 10, 101-106.
- Boguszewski, D. (2016). Analysis of the final fights of the judo tournament at Rio 2016 Olympic Games. *Journal of Combat Sports and Martial Arts*, 1(2), Vol.7, 67-72.
- Boguszewski, D., & Boguszewska, K. (2006). Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). *Archives of Budo*, 2, 40-44.
- Bakaev, V.V., Bolotin, A.E., & Aganov, S.S. (2016). Physical training complex application technology to prepare rescuers for highland operations. *Teoriya i Praktika Fizicheskoy Kultury*, (6), 6-8.
- Bolotin, A., & Bakayev, V. (2018). Pedagogical practice for development of coordination potential of MMA fighters and estimation of its efficiency. *Journal of Human Sport and Exercise*, 13(1), 72-88. doi:<https://doi.org/10.14198/jhse.2018.131.08>
- Chernozub, A., Korobeynikov, G., Mytskan, B., Korobeinikova, L., & Cynarski, W.J. (2018). Modelling mixed martial arts power training needs depending on the predominance of the strike or wrestling fighting style. *Journal of Martial Arts Anthropology*, 18(3), 28-36.
- Coswig, V.S., Ramos, S.P., & Del Vecchio, F.B. (2016). Time-motion and biological responses in simulated mixed martial arts sparring matches. *Journal of Strength and Conditioning Research*, 30, 2156-2163.
- Dal Bello, F., Brito, C.J., Amtmann, J., & Miarka, B. (2019). Ending MMA combat, specific grappling techniques according to the type of the outcome. *Journal of Human Kinetics*, 67(1), 271-280.

De Dreu, C.K., Nijstad, B.A., Baas, M., Wolsink, I., & Roskes, M. (2012). Working memory benefits creative insight, musical improvisation, and original ideation through maintained task-focused attention. *Personality & social psychology bulletin*, 38(5), 656–669. <https://doi.org/10.1177/0146167211435795>

Del Vecchio, F.B., Hirata, S.M., & Franchini, E. (2011). A review of time-motion analysis and combat development in mixed martial arts matches at a regional level tournaments. *Perceptual and Motor Skills*, 112(2), 639-648.

De Quel, O.M., Ignacio A., Izquierdo, M., & Ayán, C. (2019). Does physical fitness predict future karate success? A study in young female karatekas. *International Journal of Sports Physiology and Performance*, 15., 10.1123/ijsp.2019-0435.

Dreisbach, G., & Goschke, T. (2004). How positive affect modulates cognitive control: Reduced perseveration at the cost of increased distractibility. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30(2), 343-353.

El Ashker, S. (2011). Technical and tactical aspects that differentiate winning and losing performances in boxing, *International Journal of Performance Analysis in Sport*, 11(2), 356-364.

Fajen, B.R., Riley, M.A., & Turvey, M.T. (2009). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology*, 40(1), 79-107.

Federação Portuguesa de Full Contact, FPFC. (2018b). Caracterização do full contact, ultimate full contact e conteúdos técnico-táticos. Available from: <http://www.angelfire.com/pq/fppff/description.htm>

Fernandes, J.R., Bello, F.D., Duarte, M.A.B., Carvalho, P.H.B., Queiroz, A.C.C., Brito, C.J., & Miarka, B. (2018). Effect of rule changes on technical-tactical actions correlated with injury incidence in Professional Mixed Martial Arts. *Journal of Physical Education and Sports*, 18, 1713-1721.

Filimonov, V.I., Koptsev, K.N., Husyanov, Z.M., & Nazarov, S.S. (1985). Boxing: Means of increasing strength of the punch. *National Strength & Conditioning Association Journal*, 7(6), 65-66. [https://doi.org/10.1519/0744-0049\(1985\)007<0065:MOISOT>2.3.CO;2](https://doi.org/10.1519/0744-0049(1985)007<0065:MOISOT>2.3.CO;2)

Forbes, K., Kolliopoulos, A. (2004). Reactive motion for an animated boxer. CSC 2529: Character Animation Final Project, May 3.

Ghoul, N., Tabben, M., Miarka, B., Tourny, C., Chamari, K., & Coquart, J. (2017). Mixed martial arts induce significant fatigue and muscle damage up to 24 hours post-combat. *Journal of Strength and Conditioning Research*, 22.

Hao, Y. (2019). A brief discussion on counter attack tactics and application technique in the sanda competition. *Frontiers in Sport Research*, 1(2), 47-53.

Hristovski, R., Davids, K., Araújo, D., & Button, C. (2006). How boxers decide to punch a target: emergent behaviour in nonlinear dynamical movement systems. *Journal of sports science & medicine*, 5, 60-73.

Hristovski, R., Davids, K., Araújo, D., & Passos, P. (2011). Constraints-induced emergence of functional novelty in complex neurobiological systems: A basis for creativity in sport. *Nonlinear Dynamics, Psychology, and Life Sciences*, 15(2), 175-206.

James, L.P., Haff G.G., Kelly, V.G., & Beckman, E.M. (2016). Towards a determination of the physiological characteristics distinguishing successful mixed martial arts athletes: a systematic review of combat sport literature. *Sports Medicine*, 46 (10), 1525-1551. doi: 10.1007 / s40279-016-0493-1

James, L.P., Robertson, S., Haff, G.G., Beckman, E.M., & Kelly, V.G. (2017). Identifying the performance characteristics of a winning outcome in elite mixed martial arts competition. *Journal of Science and Medicine in Sport*, 20, 296-301.

Kassim, S.F., Suwarganda, E.K., & Nor, E.A. (2015). Successful tactics in taekwondo during Sukan Malaysia 2012. Asia Pacific Conference on Performance Analysis of Sport Langkawi, Malaysia 2014, 21-24. *Journal of Human Sport and Exercise*, 1988-5202.

Kimmel, M., & Rogler, C.R. (2019). The anatomy of antagonistic coregulation: Emergent coordination, path dependency, and the interplay of biomechanic parameters in Aikido. *Human Movement Science*, 63, 231-253.

Kirk, C., Hurst, H., & Atkins, S. (2015). Measuring the workload of mixed martial arts using accelerometry, Time motion analysis and lactate. *International Journal of Performance Analysis in Sport*, 15, 359-370.

Kostrubiec, V., Zanone, P.G., Fuchs, A., & Kelso, J.A.S. (2012). Beyond the blank slate: Routes to learning new coordination patterns depend on the intrinsic dynamics of the learner: Experimental evidence and theoretical model. *Frontiers in Human Neuroscience*, 6, 1–14.

Kruyning, E., & De Jong, M. (2014). *Mma, The essentials of mixed martial arts*. Eerste editie Edition.

Lee L. (1975). *Tao of jeet kune do by Bruce Lee*. 1st ed. CA: Ohara Publications, Inc.

Liu, Y.T., Mayer-Kress, G., & Newell, K.M. (2006). Qualitative and quantitative change in the dynamics of motor learning. *Journal of Experimental Psychology: Human Perception and Performance*, 32(2), 380-393.

Mahlo, F. *Acto tático no jogo*. 1st ed. Lisboa: Compendium; 1997.

Mann, D.T., Williams, A.M., Ward, P., & Janelle, C.M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport & Exercise Psychology*, 29(4), 457-478. <https://doi.org/10.1123/jsep.29.4.457>

Marteniuk, R.G. (1976). *Information Processing in Motor Skills*. NY: Holt, Rinehart & Winston.

Maszczyk, A., Gołaś, A., Pietraszewski, P., Kowalczyk, M., Ciężczyk, P., Kochanowicz, A., Smółka, W., & Zajac, A. (2018). Neurofeedback for the enhancement of dynamic balance of judokas. *Biology of Sport*, 35(1), 99-102.

McRobert, A.P., Ward, P., Eccles, D.W., & Williams, A.M. (2011). The effect of manipulating context-specific information on perceptual–cognitive processes during a simulated anticipation task. *British Journal of Psychology*. doi: 10.1348/2044-8295.002013

- Memmert, D. (2007). Can creativity be improved by an attention-broadening training program? An exploratory study focusing on team sports. *Creativity Research Journal*, 19(2-3), 281-291.
- Miarka, B., Brito, C.J., & Amtmann, J. (2017). Performance probabilities and outcome effects in technical–tactical factors with bout phase changes of mixed martial arts. *International Journal of Performance*, 17, 510-520.
- Miarka, B., Brito, C.J., Dal Bello, F., & Amtmann, J. (2017). Motor actions and spatiotemporal changes by weight divisions of mixed martial arts: Applications for training. *Human Movement Science*, 55, 73-80.
- Miarka, B., Coswig, V.S., & Amtmann, J. (2019) Long MMA fights technical-tactical analysis of mixed martial arts: implications for assessment and training, *International Journal of Performance Analysis in Sport*, 19, 2, 153-166. DOI:10.1080/24748668.2019.1579030
- Miarka, B., Coswig, V., Brito, C.J., Slimani, M., Amtmann, J., & Del Vecchio, F.B. (2016). Comparison of combat outcomes: Technical and tactical analysis of female mma. *International Journal of Performance*, 16, 1-13.
- Miarka, B., Vecchio, F.B., Camey, S., & Amtmann, J.A. (2016). Comparisons: Technical-tactical and time-motion analysis of mixed martial arts by outcomes. *Journal of Strength and Conditioning Research*, 30, 1975-1984.
- Miarka, B., Sterkowicz-Przybycien, K., & Fukuda, D.H. (2017a) Evaluation of sex-specific movement patterns in judo using probabilistic neural networks. *Motor Control*, 21, 390-412.
- Moraru, A., Memmert, D., & Van der Kamp, J. (2016). Motor creativity: The roles of attention breadth and working memory in a divergent doing task. *Journal of Cognitive Psychology*, 28(7), 856-867.
- Nijstad, B.A., De Dreu, C.K., Rietzschel, E.F., & Baas, M. (2010). The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence. *European Review of Social Psychology*, 21(1), 34-77.

North, J.S., Williams, A.M., Hodges, N.J., Ward, P., & Ericsson, K.A. (2009). Perceiving patterns in dynamic action sequences: Investigating the processes underpinning stimulus recognition and anticipation skill. *Applied Cognitive Psychology*, 23, 878-894.

Orth, D., van der Kamp, J., Memmert, D., & Savelsbergh, G. (2017). Creative motor actions as emerging from movement variability. *Frontiers in Psychology*, 8, 1903.

Ottoboni, G., Russo, G., & Tessari, A. (2015). What boxing-related stimuli reveal about response behaviour. *Journal of Sports Sciences*, 33(10), 1019-1027. <https://doi.org/10.1080/02640414.2014.977939>.

Pinto, F.C.L. (2015). *Perceção sobre as competências do treinador de desportos de combate* (Master's Thesis). Instituto Politécnico da Guarda, Guarda, Portugal. Available from: <http://hdl.handle.net/10314/2279>

Russo, G., & Ottoboni, G. (2019). The perceptual – cognitive skills of combat sports athletes: A systematic review. *Psychology of Sport and Exercise*, 44, 60-78.

Sarmiento, P. (2005). *A função pedagógica do treinador: Uma abordagem comportamental*. *Treino Desportivo*, 6, 46-51.

Sterkowicz-Przybycien, K., Miarka, B., & Fukuda, D.H. (2017). Sex and weight category differences in time-motion analysis of elite judo athletes: Implications for assessment and training. *Journal of Strength and Conditioning Research*, 31, 817-825.

Thelen, E. (1995). Motor development: A new synthesis. *American Psychologist*, 50(2), 79-95.

Urquidez, B. (1981). *Training and fighting skills*. 1st ed. CA: Unique Publications, Inc.

Vidranski, T., Maškarin, F., & Jukić J. (2015). Differences in technical and tactical indicators of attacks and counterattacks in elite male karate fighters. *Acta Kinesiologicaogica*, 1(9), 19-24.

Wallace B. (1982). *Dynamic stretching & kicking*. 1st ed. CA: Unique Publications, Inc.

Warren, W.H. (2006). The dynamics of perception and action. *Psychological Review*, 113(2), 358-389.

Williams, A.M., Ford, P.R., Eccles, D.W., & Ward, P. (2010). Perceptual-cognitive expertise in sport and its acquisition Implications for applied cognitive psychology. *Applied Cognitive Psychology*. doi: 10.1002/acp.1710

Withagen, R., & Van der Kamp, J. (2018). An ecological approach to creativity in making. *New Ideas in Psychology*, 49, 1-6. <https://doi.org/10.1016/j.newideapsych.2017.11.002>.