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Review

The Influence of Anthropometric Characteristics on Punch Impact

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Abstract: Objective: This review examined the influence of anthropometric characteristics, such as height and body mass, on the impact of punches in striking combat sports. Despite their perceived importance for combat strategy, the relationship between these characteristics and punch impact remains unclear. **Methods:** We included Experimental, Quasi-experimental and Cross-sectional studies. The search was conducted on August 30, 2024, in three databases. The review analyzed 23 studies involving 381 participants (304 men, 30 women, 47 unknown gender). Various instruments were used in the included studies, including 10 instruments to measure impact force and 2 instruments to measure impact power. **Results:** Impact force ranged from 989 ± 116.76 to 5008.6 ± 76.3 N, with rear hand straight punches and rear hand hooks producing the greatest force. The PowerKube revealed that the rear hand straight punch generated the highest power, ranging from 15183.27 ± 4368.90 to 22014 ± 1336 W. While heavier weight categories were associated with stronger punches, body mass alone was not the only predictor. Other factors, such as technique, gender, and sport type, also played roles. The relationship between height and punch impact showed mixed results. **Conclusion:** The data suggest that while higher weight categories are associated with greater punch impact, body mass is not the only determining factor. The relationship between height and impact also showed mixed results, with no clear association. The review highlights the lack of a gold standard instrument for evaluating punch impact.

Keywords: Combat Sport; Punch; Anthropometric Characteristics; Impact Force; Impact Power

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1. Introduction

Empirically, certain anthropometric characteristics have been noted as crucial for the technical profile of athletes in striking combat sports, characterized by the application of striking techniques that influence their combat strategies. Striking combat sports aim for temporary incapacitation or the accumulation of points, according to the specific rules of each discipline [1,2].

It has been shown that the choice of punch depends on the distance, position, and movement relative to the target, with height and reach being important variables for punch success [3,4]. However, despite these variables being considered important, their relationship with victory remains inconclusive [5,6].

The literature on the technical analysis of striking combat sports is diverse but inconclusive. Over the past two decades, the technical profile of athletes and the variables influencing their decisions during movements have been analyzed [3,5]. In this context, most punches in striking combat sports can be divided into three types: (a) straight punches (front-facing strikes), (b) hooks (lateral movements), and (c) uppercuts (vertical movements) [3].

To increase the likelihood of finishing a fight by incapacitating the opponent, the impact generated by punches has been widely analyzed [7–9]. Broadly speaking, the effectiveness of punch impact is a complex movement involving both upper and lower body muscles and the proper cooperation of agonist and antagonist muscles [1,10–15]. In this regard, Filimonov et al. 1985 [11] stated that rear hand punches can be divided into three main components to generate impact: (a) contribution of arm muscles to the target, (b) trunk rotation, and (c) leg propulsion from the ground [11]. Similarly, Ruddock et al. 2016 [16], mentioned three factors that contribute to punch effectiveness: (a) the speed of muscle group activation, (b) arm propulsion, and (c) muscle activation at the moment of impact to effectively transfer displaced mass, termed "stiffening" [16].

Moreover, evidence shows variations in impact levels between punch types, different weight categories, and athletes' limb lengths [17,18].

According to the literature, there are three types of punch impact evaluation in combat sports athletes: (a) direct evaluation of relevant inertia, using load cells and platforms directly connected to the target, providing a direct measure of applied impact (e.g., force platforms); (b) indirect evaluation of relevant inertia, involving the indirect measurement of impact by calculating changes in the target's acceleration caused by impact instead of directly measuring force (e.g., observing bag movement in slow-motion footage); (c) evaluation of impact on the athlete's limb, such as the fist, using measuring devices (e.g., load cells in boxing gloves) [4].

Additionally, various studies have measured punch impact using units like force (N), power (W), velocity (m/s), acceleration (m/s²), gravitational acceleration (g), and mass (kg) [9,18–24]. The International System of Units for force is the newton (N), and while many studies analyze punch force in newtons, the dynamic nature of punches requires measuring impact power in watts (W) [25,26]. Power describes the amount of work done per unit of time [26]. This concept appears crucial to evaluating the intensity and effectiveness of a punch, as it directly relates the force applied and the punch's execution speed [25].

The aim of this systematic review is to verify the current state of research regarding the analysis of the influence of anthropometric characteristics on punch impact. We hypothesize that anthropometric characteristics, such as height and body mass, influence punch impact. The studies included in this review cover the period from 2000 to 2020.

2. Methods

This systematic literature review was conducted following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [27]. The review was registered on the INPLASY website with the registration number: INPLASY202480138 and DOI: 10.37766/inplasy2024.8.0138.

2.1. Eligibility Criteria

All studies published to date that report participants' anthropometric characteristics (e.g., height, body mass) related to the analysis of punch impact in Newton (N) or Watt (W) units were included. All types of studies were considered for inclusion in the review, except qualitative studies, systematic reviews, and meta-analyses. This review was limited to articles published in English.

2.2. Search Strategy

The search was conducted using the electronic databases PubMed, SPORTDiscus, and Web of Science to identify and select relevant studies for inclusion in this review, combining three sets of terms: (i) terms related to the population of interest; (ii) terms related to anthropometric characteristics; (iii) terms related to punch techniques. The following search terms were used: (boxing OR combat sports OR muay thai OR kickboxing OR karate OR mma OR kung fu) AND (height OR anthropometric characteristics OR body measurements OR anthropometry OR physical attributes) AND (punch OR strength OR impact force OR power OR performance OR activity profile OR punch performance). The search was conducted on August 30, 2024. Additionally, a manual search of the literature cited in articles and in reference journals was performed.

2.3. Study Selection, Data Extraction, and Synthesis

The articles identified in the search were initially deemed potentially eligible based on their titles and abstracts. After a full review and based on the eligibility criteria, the articles for this review were selected. Zotero for Windows was used to manage the references. A specific form was developed for data extraction, including information on: i. Study characteristics: authors, year of publication, and design; ii. Sample characteristics: size, gender, age, height, body mass, body mass index (BMI); iii. Type of Sport; iv. Anthropometric characteristics; v. Measurement instruments; vi. Main results.

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The qualitative synthesis of the data was presented in a table format. The extracted characteristics and variables are organized by study, in alphabetical order (Tables 1 and 2).

2.4. Quality Assessment of Studies

To assess the quality of the included studies, an adapted version of the Quality Assessment Tool for Quantitative Studies from the Effective Public Health Practice Project was used [28], recommended by the Cochrane Public Health Review Group [29] and previously applied by Teixeira et al. 2015 [30]. This tool allows for the assessment of experimental and observational studies in eight domains: representativeness (selection bias); study design; confounding factors; blinding; data collection; data analysis; results presentation; and representativeness (exclusions/dropouts). Each domain is classified as strong (good methodological quality), moderate, or weak (low methodological quality), with the final assessment determined according to the evaluations of each domain.

3. Results

3.1. Description of the Included Studies

The search of the literature performed in the databases PubMed, SPORTDiscus, and Web of Science resulted in 1849 potential studies (Figure 1). Subsequently, 10 studies were added manually. Of the 1859 studies initially identified, 68 were removed as duplicates. A total of 1749 studies were excluded based on title and abstract. The main reasons for exclusion at this stage were that the articles did not report the anthropometric characteristics of the sample or did not present results of interest for the review (e.g., magnitude of punch impact). Additionally, qualitative studies, systematic reviews, and meta-analyses were excluded at this stage. As a result, 42 articles were considered potentially eligible for full-text reading. After reviewing the full texts of the selected articles, 23 were selected that met the inclusion criteria for this literature review.

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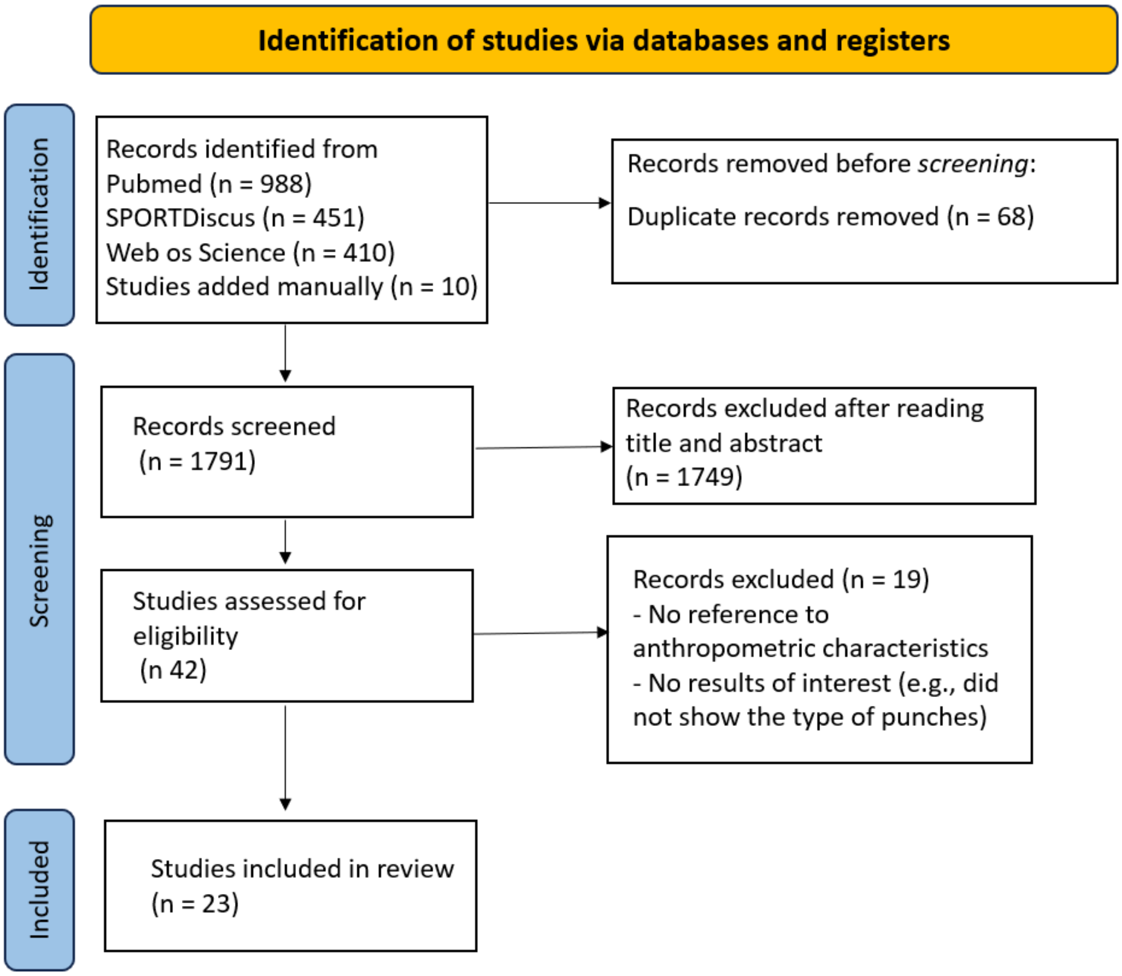

Figure 1. Flowchart according to PRISMA 2020 guidelines.

3.2. Characteristics of the Studies

Tables 1 and 2 detail the characteristics of the studies included in this analysis. The majority of studies (k = 18) had a cross-sectional observational design, three studies had an experimental design, and two were quasi-experimental.

3.3. Participant Characteristics

A total of 381 participants (men = 304; women = 30; unknown gender = 47) were included in the 23 studies (Tables 1 and 2). The average age of these samples ranged from 17.5 ± 0.5 to 47.5 ± 10.13 years, with an average height ranging from 172 ± 10 to 182 ± 5 cm, and body mass ranging from 64.56 ± 12.1 kg to 86.8 ± 17 kg.

3.4. Impact Force

Regarding impact force, a total of 262 participants (men = 186; women = 29; unknown gender = 47) were included in the 16 studies (Table 1). The average age of these samples ranged from 17.5 ± 0.5 to 47.5 ± 10.13 years, height ranged from 172 ± 10 to 182 ± 5 cm, and body mass ranged from 64.56 ± 12.1 kg to 86.8 ± 17 kg.

To simplify the various terminologies presented in the literature, we chose to define the force measurement devices reflected in this review (e.g., dynamometer, load cell, force sensor) as load cells, as this is the most common definition in the literature and facilitates interpretation, given that all these devices are specific instruments for measuring impact force. Thus, we identified the following 10 different instruments: (1) Accelerometer inserted into the dummy's head and participants' gloves;

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(2) Tri-axial accelerometer inserted into the dummy's head; (3) Target with accelerometer and load cell inserted; (4) Target with a load cell specific for boxing and a force transducer; (5) Target on a board with a load cell on the side, transducer, and software; (6) Load cell inserted in the wall bag, with transducer and software; (7) Load cell inserted in the target, with transducer and software; (8) Load cell inserted in the boxing bag, with transducer and software; (9) Force platform with a cushioned target; (10) Boxing bag with a load cell and gyroscope transducer inserted. To facilitate the analysis of impact force data, we included studies that presented values in Newton (N) units, identifying the highest impact force values by instrument (Figure 2), as well as the type of instrument and main results (Table 1).

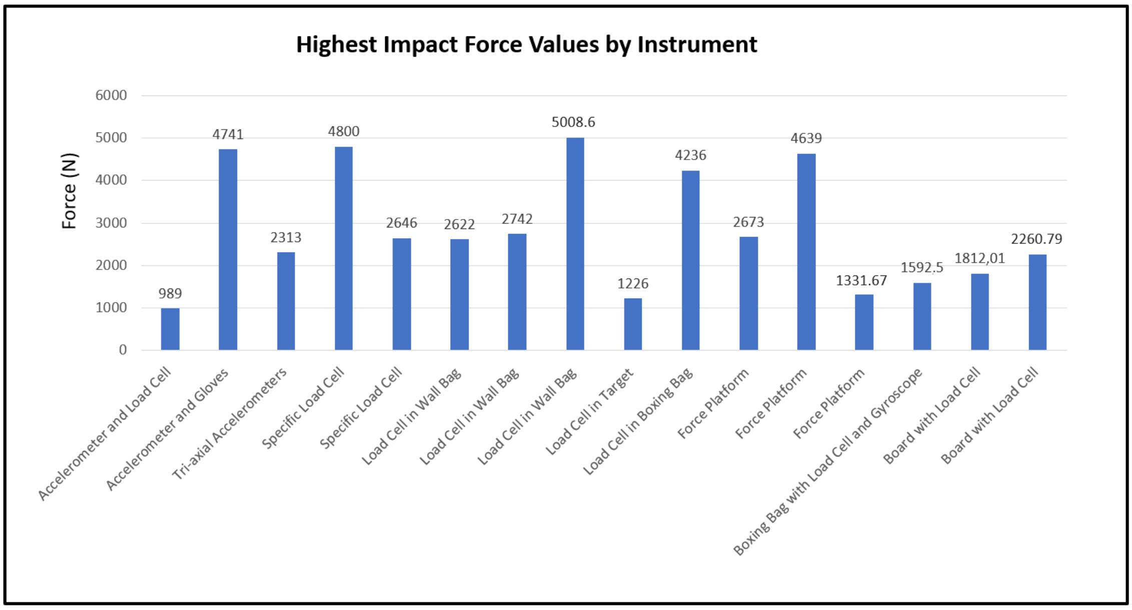

Figure 2. Highest Impact Force Values by Instrument.

Note: Accelerometer and Load Cell = Target with an accelerometer and load cell inserted; Accelerometer and Gloves = Accelerometer inserted in the dummy's head and the participants' gloves; Tri-axial Accelerometers = Tri-axial accelerometers inserted in the dummy's head; Specific Load Cell = Target with a load cell specific to boxing and force transducer; Load Cell in Wall Bag = Load cell inserted in the wall bag, with transducer and respective software; Load Cell in Target = Load cell inserted in the target, with transducer and respective software; Load Cell in Boxing Bag = Load cell inserted in the boxing bag, with transducer and respective software; Force Platform = Force platform with cushioned target; Boxing Bag with Load Cell and Gyroscope = Boxing bag with load cell and an inserted gyroscope transducer; Board with Load Cell = Target on a board with a lateral load cell, transducer, and respective software.

3.5. Impact Power

Regarding impact power, a total of 119 participants (men = 118; women = 1) were included in the 7 studies (Table 2). The average age of these samples ranged from 24 ± 4 to 29 ± 2 years, average height ranged from 176.7 ± 6.2 to 181.72 ± 8.28 cm, and body mass ranged from 76 ± 7.2 to 80.9 ± 12.24 kg. The studies evaluated only straight punches, where the cross consistently showed higher values than the jab (front hand direct punch).

The studies that analyzed power used only two instruments, the PowerKube and the StrikeMate, which are similar with minor differences (name and appearance). The device in question is a portable and lightweight impact cube, specifically designed to measure and analyze the impact power of punches. Inside the cube are two high-precision accelerometers responsible for detecting and quantifying the acceleration caused by impacts [31].

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3.6. Results Synthesis

All studies (k = 23) mention at least one of the participants' anthropometric characteristics (Tables 1 and 2).

Regarding impact force, the most commonly used instruments in the studies were those with load cells inserted in the wall bag, equipped with transducers and appropriate software (k = 3), and force platforms with cushioned targets (k = 3). Both instruments, which are direct methods of relevant inertia assessment, showed the punches with the highest values, rear hand cross and hook, with an average impact force ranging from 1331.67 ± 234.49 to 5008.6 ± 76.3 N. The highest impact force levels per instrument ranged from 989 ± 116.76 to 5008.6 ± 76.3 N, with the rear hand straight punch (cross) and rear hand hook identified as generating the highest impact force levels (Table 1). The instrument that demonstrated the highest impact force values was the one with load cells inserted in the wall bag (Figure 2).

Regarding impact power, all studies used the same type of direct instrument for relevant inertia assessment. This instrument identified the cross as the punch with the highest value, with an average impact power ranging from 15183.27 ± 4368.90 to 22014 ± 1336 W (Table 2).

3.7. Methodological Quality of the Studies

Tables 3 and 4 present the methodological quality of the studies. Most studies (k=21) were rated as having "moderate" methodological quality due to the study design, low sample power, and lack of representativeness of the population studied. Two studies were rated as having "strong" methodological quality.

Table 1. Characteristics of participants, type of sport, anthropometric characteristics, instruments, mean and maximum impact force in Newton (N) units of measurement.

Reference	Study design	Participants	Type of sport	Anthropometric Characteristics	Instruments	Main results
Adamec et al., 2021 [32]	Cross-sectional	N = 50 (men = 29; women = 21); Age: 34 years; Height: 174 cm; Weight: 76 kg.	Karate.	Height, weight.	Force platform with cushioned target (DIRA).	Fmax - Straight punch (4639 N).
Buśko et al., 2016 [33]	Cross-sectional	N = 13 men; Age: 17.5 years; Height: 175.5 cm; Weight: 69kg.	Boxing.	Height, weight.	Boxing bag with load cell and an inserted gyroscope transducer (DIRA).	Fmean - Cross (1592.5 ± 507.1 N).
Chadli et al., 2014 [34]	Cross-sectional	N = 11 (unknown gender); Age: 23.5 ± 0.5 years; Height: 179 ± 9 cm;	Boxing.	Height, weight.	Target with an accelerometer and load cell inserted (DIRA).	Fmean - Punch (989 ± 116.76 N).

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		Weight: 77.39 ± 11 kg.				
Dunn et al., 2019 [35]	Cross-sectional	N = 15 men; Age: 17.5 ± 0.5 years; Height: 177.5 ± 9 cm; Weight: 73 ± 14 kg.	Boxing.	Height, weight.	Load cell inserted in the wall bag, with transducer and respective software (DIRA).	Fmean - Jabs (841 ± 180 N); Cross (1818 ± 332 N); Hooks (2622 ± 288 N).
Dunn et al., 2022 [36]	Cross-sectional	N = 28 men; Age: 19 ± 2 years; Height: 177 ± 7.3 cm; Weight: 70,5 ± 11 kg.	Boxing.	Height, weight.	Load cell inserted in the wall bag, with transducer and respective software (DIRA).	Fmean - Jab (823 ± 271 N); Cross (1830 ± 387 N); Lead hand hook (2491 ± 492 N); Rear hand hook (2742 ± 571 N).
Dyson et al., 2005 [37]	Cross-sectional	N = 6 men; Age: 24.5 ± 3.3 years; Height: 182 ± 5 cm; Weight: 73.3 ± 19 kg.	Boxing.	Height, weight.	Load cell inserted in the boxing bag, with transducer and respective software (DIRA).	Fmean - Cross (4236 ± 181 N); Jab (2722±75 N).
Finlay, 2022 [38]	Experimental	N = 10 men; Age: 19.7 ± 1.2 years; Height: 180.9 ± 7.0 cm; Weight: 78.7 ± 9.6 kg.	Boxing.	Height, weight.	Force platform with cushioned target (DIRA).	Fmax - Rear hand hook (2673 N); Lead hand hook (2565 N); Cross (2538 N).
Kim et al., 2018 [8]	Quasi-experimental	N = 15 men; Age: 23.4 years; Height: 176.5 cm; Weight: 67.7 kg.	Boxing.	Height, weight.	Tri-axial accelerometers inserted in the dummy's head (DIRA).	Fmax - Cross (2313 N).
Lee & McGill, 2017 [39]	Quasi-experimental	N = 12 men;	Muay Thai.	Height, weight.	Load cell inserted in the wall bag, with	Fmean - Jab (3093.7 ± 69.4 N); Cross (5008.6 ± 76.3 N); Knee (9482 ± 152.8 N).

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		Age: 24.2 ± 2.9 years; Height: 180 ± 5 cm; Weight: 76.8 ± 9.7 kg.			transducer and respective software (DIRA).	
Loturco et al., 2016 [14]	Cross-sectional	N = 15 (men = 9; women = 6); Age: 25.9 ± 4.7years; Height: 172 ± 10 cm; Weight: 64.56 ± 12.1 kg.	Boxing.	Height, weight.	Force platform with cushioned target (DIRA).	Fmean - Jab men (1152.22 ± 246.87 N); Cross men (1331.67 ± 234.49 N); Jab women (902.50±213.49 N); Cross women (994.17±221.14 N).
Neto et al., 2009 [40]	Cross-sectional	N = 12 (men = 10; women = 2); Age: 23.4 years; Height: 174.7 ± 4 cm; Weight: 70.9 ± 12 kg.	Kung Fu.	Height, weight.	Load cell inserted in the target, with transducer and respective software (DIRA).	Fmax - Punch (1226 N).
Smith et al., 2000 [41]	Cross-sectional	N = 23 men; Age: 23.1 ± 1.2 years; Height: 178 ± 6 cm; Weight: 69.9 ± 8.6 kg.	Boxing.	Height, weight.	Target with a load cell specific to boxing and force transducer (DIRA).	Fmean - Cross – Elite (4800 ± 227 N), intermediate (3722 ± 133 N), beginner (2381 ± 116 N).
Smith, 2006 [9]	Cross-sectional	N = 29 (unknown gender); Age: 21 ± 2 years; Height: 174 ± 8 cm; Weight: 67 ± 10 kg.	Boxing.	Height, weight.	Target with a load cell specific to boxing and force transducer (DIRA).	Fmean - Jab to the face (1722 ± 700 N), to the body (1682 ± 636 N); Cross to the face (2643 ± 1273 N), to the body (2646 ± 1083 N); Lead hand hook to the face (2412 ± 813 N), to the body (2414 ± 718 N); Rear hand hook to the face (2588 ± 1040 N), to the body (2555 ± 926 N).
V. A. de Souza & Marques	Cross-sectional	N = 8 men;	Karate.	Height, weight.	Target on a board with a lateral load cell,	Fmax - Straight punch (1812.01 N).

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, 2017 [42]		Age: 20.25 ± 4.13 years; Height: 174 ± 4 cm; Weight: 72.41 ± 9.6 kg.			transducer, and respective software (DIRA).	
V. de Souza & Marques , 2017 [43]	Cross-sectional	N = 8 men; Age: 47.5 ± 10.13 years; Height: 176 ± 3 cm; Weight: 86.8 ± 17 kg.	Karate.	Height, weight.	Target on a board with a lateral load cell, transducer, and respective software (DIRA).	Fmean - Straight punch (2260.79 ± 538.44 N).
Walilko et al., 2005 [24]	Cross-sectional	N = 7 (unknown gender); Weight: 48 a 109kg.	Boxing.	Weight.	Accelerometer inserted in the dummy's head and the participants' gloves (DIRA e AL).	Fmax - Straight punch (4741 N). Weight categories: Flyweight (3914 N); Light welterweight (3621 N); Middleweight (3072 N); Super heavyweight (4741 N).

DIRA = Direct inertia-relevant assessment; AL = Assessment on the athlete's limb; Jab = Straight punch with the lead hand; Cross = Straight punch with the rear hand; Fmax = Maximum punch force; Fmean = Mean punch force.

Table 2. Characteristics of participants, type of sport, anthropometric characteristics, instruments, mean and maximum impact power in Watts (W) units of measurement.

Reference	Study design	Participants	Type of sport	Anthropometric Characteristics	Instruments	Main results
Brown et al., 2020 [44]	Cross-sectional	N = 15 men; Age: 24.2 ± 2.9 years; Height: 176.7 ± 6.2 cm; Weight: 79.3 ± 11.8 kg; BMI: 24.9 kg.m-2.	Boxing	Height, weight.	PowerKube (DIRA).	Pmean - Cross (15227.4 ± 225 W).
Brown et al., 2021 [45]	Experimental	N = 20 men; Age: 28 ± 6 years; Height: 178 ± 4 cm;	Boxing.	Height, weight.	PowerKube (DIRA).	Pmean - Cross (22014±1336 W).

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		Weight: 76.5 ± 10 kg.				
Brown et al., 2022 [21]	Cross-sectional	N = 22 men; Age: 28 ± 2 years; Height: 178 ± 8.1 cm; Weight: 79 ± 7.1 kg; BMI: 24.9 ± 2.5 kg.m-2.	Boxing	Height, weight.	PowerKube (DIRA).	Pmean - Cross (15227 ± 2250 W).
Brown et al., 2023 [46]	Cross-sectional	N = 16 (men = 15; women = 1); Age: 24 ± 4 years; Height: 181.72 ± 8.28 cm; Weight: 80.16 ± 11.32kg.	Boxing; Muay Thai	Height, weight.	PowerKube (DIRA).	Pmean - Cross (19640 ±1410 W).
Del Vecchio et al., 2018 [47]	Experimental	N = 17 men (10 EG; 6 CG); Age: 28 ± 2 (EG) e 29 ± 2 (CG) years; Height: 178 ± 8.1 (EG) e 177.7± 5.7 (CG) cm; Weight: 79 ± 7.1 (EG) e 79.8 ± 11.9 (CG) kg.	Combat sports (not specified)	Height, weight.	StrikeMate (DIRA).	Pmean - Jab (6781.6 ± 2178.9 W); Cross (15335.9 ± 4432.8 W); Front kick (8357.5 ± 2895.9 W); Roundhouse kick (40129.2 ± 10169.8 W).
Del Vecchio et al., 2019 [48]	Experimental	N = 16 men (10 EG; 6 CG); Age: 25.2 ± 1.8 (EG) e 29 ± 2(CG) years; Height:178.1 ± 7.1(EG) e 177.7 ± 5.7 (CG) cm; Weight: 76 ± 7.2 (EG) e 79.8 ± 11.9 (CG) kg.	Combat sports (not specified)	Height, weight.	StrikeMate (DIRA).	Pmean - Jab (7478.82 ± 2994.36 W); Cross (15183.27 ± 4368.90 W); Front kick (7438.64 ± 1910.56 W); Roundhouse kick (45278.30 ± 11323.13 W).

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Del Vecchio et al., 2021 [49]	Cross-sectional	N = 13 men; Age: 28.8 ± 4.57 years; Height:176.9 ± 4.14 cm; Weight: 80.9 ± 12.24 kg; BMI: 25.9 ± 3.8 kg.m-2.	Combat sports (not specified)	Height, weight.	StrikeMate (DIRA).	Pmean - Jab (8081 ± 3742 W); Cross (15431 ± 4294 W); Front kick (8563 ± 3095 W); Roundhouse kick (46377 ± 12209 W).

AL = Assessment on the athlete's limb; DIRA = Direct inertia-relevant assessment; EG = Experimental group; CG = Control group; Jab = Straight punch with the lead hand; Cross = Straight punch with the rear hand; Pmax = Maximum punch power; Pmean = Mean punch power.

Table 3. Assessment of the methodological quality of studies on the impact force of punches.

REFERENCE	STUDY DESIGN	BLINDING	REPRESENTATIVITY (SELECTION BIAS)	SAMPLE REPRESENTATIVITY (DROPOUTS)	CONFOUNDING FACTORS	DATA COLLECTION	DATA ANALYSIS	PRESENTATION OF RESULTS	OVERALL CLASSIFICATION
Adamec et al., 2021 [32]	2	3	3	4	2	1	1	1	moderate
Buśko et al., 2016 [33]	2	3	3	4	2	1	1	1	moderate
Chadli et al., 2014 [34]	2	3	3	4	2	1	1	1	moderate
Dunn et al., 2019 [35]	2	3	2	4	2	1	1	1	moderate
Dunn et al., 2022 [36]	2	3	2	4	2	1	1	1	moderate
Dyson et al., 2005 [37]	2	3	2	4	2	1	1	1	moderate
Finlay, 2022 [38]	1	3	3	1	1	1	1	1	strong
Kim et al., 2018 [8]	1	3	3	1	2	1	1	1	moderate

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Lee & McGill, 2017 [39]	1	3	3	1	1	1	1	1	strong
Loturco et al., 2016 [14]	2	3	2	4	2	1	1	1	moderate
Neto et al., 2009 [40]	2	3	2	4	2	1	1	1	moderate
Smith et al., 2000 [41]	2	3	1	4	2	1	1	1	moderate
Smith, 2006 [9]	2	3	1	4	3	1	1	1	moderate
V. A. de Souza & Marques, 2017 [42]	2	3	3	4	2	1	1	1	moderate
V. de Souza & Marques, 2017 [43]	2	3	3	4	2	1	1	1	moderate
Walilko et al., 2005 [24]	2	3	3	4	3	1	1	1	moderate

Legend: 1 = Strong; 2 = Moderate; 3 = Weak; 4 = No rating.

Table 4. Assessment of the methodological quality of studies on the impact power of punches.

REFERENCE	STUDY DESIGN	BLINDING	REPRESENTATIVITY (SELECTION BIAS)	SAMPLE REPRESENTATIVITY (DROPOUTS)	CONFOUNDING FACTORS	DATA COLLECTION	DATA ANALYSIS	PRESENTATION OF RESULTS	OVERALL CLASSIFICATION
Brown et al., 2020 [44]	2	3	3	4	2	1	1	1	moderate
Brown et al., 2021 [45]	2	3	3	4	2	1	1	1	moderate

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Brown et al., 2022 [21]	2	3	3	4	2	1	1	1	moderate
Brown et al., 2023 [46]	2	3	3	4	2	1	1	1	moderate
Del Vecchio et al., 2018 [47]	1	2	3	1	2	1	1	2	moderate
Del Vecchio et al., 2019 [48]	1	2	3	1	2	1	1	2	moderate
Del Vecchio et al., 2021 [49]	2	3	3	4	2	1	1	1	moderate

Legend: 1 = Strong; 2 = Moderate; 3 = Weak; 4 = No rating.

4. Discussion

Striking combat sports are highly complex and aim to deliver effective strikes while minimizing exposure to counterattacks [20,32]. Athletes perform various punches that can be influenced by individual characteristics such as body mass, height, limb length, and muscle mass, which appear to play a crucial role in determining punch impact [17,23,24].

Our literature review specifically focused on the influence of anthropometric factors on punch impact. The data suggest that while higher weight categories generally correspond to greater punch impact, body mass alone does not determine punch impact. Other factors, such as technique, strength, limb length, gender, and the type of sport, are also important. For example, studies comparing athletes of different weights show that athletes with higher average body mass tend to generate higher impact forces, but differences in punch impact are not always straightforward [14,42]. Upon examining the studies where body mass was analyzed, we found that athletes with higher body mass produced greater impact forces. In this regard, Loturco et al. 2016 [14] reported lower force levels (1331.67 ± 234.49 N) for participants with an average body mass of 64.56 ± 12.1 kg, while de Souza and Marques 2017 [43] observed higher impact force levels (2260.79 ± 538.44 N) in participants with an average body mass of 86.8 ± 17 kg [43]. However, Loturco et al. 2016 [14] study included participants of both genders, which may have introduced bias, as men typically produce higher punch impact forces [14]. Studies involving only male participants with similar body mass (67.7 kg and 67 ± 10 kg) reported higher impact forces than the study by de Souza and Marques 2017 [43], indicating that while body mass influences impact force, it is not the only determining factor [8,9,43].

Contrary to the assumption that athletes with higher body mass consistently produce punches that generate more impact, our review revealed mixed findings regarding body mass and impact power. For instance, participants with lower body mass (76.5 ± 10 kg) exhibited higher impact power (22014 ± 1336 W) compared to those with higher body mass (80.9 ± 12.2 kg), who showed lower impact power (15431 ± 4294 W) (Table 3). This variation may be attributed to differences in the types of combat sports, as participants with higher body mass were not specified as specialists in punching techniques (e.g., boxing practitioners), which could explain the lower impact power [49].

When exploring the relationship between height and punch impact, no clear causal relationship was found. While a group of participants with an average height of 178 ± 4 cm demonstrated the highest impact power (22014 ± 1336 W), those with slightly taller (181.7 ± 8.3 cm) and shorter (176.7 ± 6.2 cm) heights exhibited lower impact powers (19640 ± 1410 W and 15227 ± 225 W, respectively). The small height differences among participants may have limited the ability to detect a consistent relationship between height and punch impact power.

5. Limitations

The aim of this review was to reflect on what the literature mentions regarding anthropometric characteristics and punch impact; however, relevant studies with information on each variable may have been excluded for not meeting the inclusion criteria. One of the main reasons was the lack of presentation of the participants' anthropometric characteristics and/or the use of different measurement units to analyze punch impact. According to the literature, several studies measured punch impact using units such as force (N), power (W), velocity (m/s), acceleration (m/s^2), gravitational acceleration (g), and mass (kg). These units were evaluated with different instruments, such as accelerometers, high-speed cameras, force platforms, load cells, and transducers. This diversity of equipment and measurements complicates standardization and analysis of results, potentially causing bias. Thus, only studies with measurements in Newtons (N) and Watts (W) were included.

Another limitation was the homogeneity of the samples. This lack of diversity may have compromised the ability to detect significant differences in punch impact among athletes with different anthropometric characteristics.

6. Conclusion

Although body mass and height may influence punch impact, the relationship between these factors is complex and multifaceted. Our analysis suggests that while anthropometric characteristics may play an important role, other factors, such as technical skill, training methods, and types of combat sports, are also significant determinants of punch performance. Additionally, more focused studies on how anthropometric characteristics interact with technical skills and individual physical capabilities could provide a deeper understanding of punch performance, ultimately leading to more targeted training strategies in striking combat sports.

7. Future Implications

Future research should include more diverse samples in terms of anthropometric characteristics to better elucidate how these variables influence punch impact. The creation and use of a gold standard instrument would facilitate the standardization of analysis methods for measuring punch impact, which is crucial for advancing research in this area, allowing for the comparison of results between different studies and the identification of more consistent patterns among distinct samples. Studies aimed at analyzing the influence of anthropometric characteristics and the strength/power of upper and lower limbs on the performance of different punching techniques will contribute to a deeper understanding of the determining factors in generating impact in these movements.

Declarations

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Conflict of interest

The authors declare no conflict of interest with respect to the authorship or the publication of this article.

Data availability

All original data are freely available in electronic database.

Ethics approval

As a systematic review and synthesis of primary findings, we did not directly interact with human subjects for this study.

Authors' contributions

Conception of the study design: all authors; literature search and selection: MP; study coding and preparation of the data set: JC; data analysis: GS and LM; writing, reviewing, editing, and final approval of the manuscript: all authors.

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