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*Systematic Review*

# The Impact of Wetsuit Use on Swimming Performance, Physiology and Biomechanics: A Systematic Review

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**Abstract:** This systematic review aims to summarize the effects of wearing different types of wetsuits and swimsuits in front crawl swimming performance and physiological- and biomechanical-related variables. The Web of Science, PubMed, Scopus and the Proceedings of the International Symposium on Biomechanics and Medicine in Swimming databases were searched from inception to 25th March 2022. From the 1398 studies initially found, 26 studies were included in the review. The quality assessment and inter-rater reliability between researchers were conducted. The full body was the most studied wetsuit, with its use allowing 3.2–12.9% velocity increments in distances ranging from 25 to 1500 m, in incremental tests, in 5 and 30 min continuous swimming and in open water events. The sleeveless long vs. the full-body wetsuit led to a 400–800 m performance enhancement. Higher stroke rate, stroke length and stroke index were observed while using three different covered body part wetsuits vs. a regular swimsuit, with a lower energy cost being observed when swimming with the full-body wetsuit compared to a swimsuit. These findings provide useful information for coaches, swimmers and triathletes about the full-body and sleeveless long/short wetsuit use, since these three wetsuits allow improving swimming performance in different distances in diverse aquatic environments.

**Keywords:** open water; triathlon; suit; neoprene; full body; temperature



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## 1. Introduction

The wetsuit was originally implemented in open water swimming to prevent hypothermia [1]. Depending on the water temperature and aiming to ensure swimmers' safety, both the International Swimming Federation and the International Triathlon Union oblige the use of wetsuits to maintain a stable body temperature [2–5]. These regulations determine a maximal thickness of 5 mm during open water and triathlon competitions to guarantee a level playing field [3,4]. The permitted wetsuit is composed of neoprene fabrics with small gas bubbles contained in synthetic rubber that produces thermal insulation due to the reduction in convective heat loss. Some wetsuits are not composed only of rubber, but also of single jersey knitted fabrics. The thickness composition can be uniform or non-uniform along the wetsuit, guaranteeing the thermal properties [6].

In addition to the thickness differences, wetsuits can also be distinguished according to the covered body part, i.e., full body (covering both upper and lower limbs up to the wrists and ankles but not the head), sleeveless long (covering the lower limbs up to the ankles but not the head nor the upper limbs) and sleeveless short (covering the torso and lower limbs up to the knees but not the head nor the upper limbs). These three wetsuit types have been analyzed because they are frequently used at competitive events and were already validated by the above-referred sport federations [3,4,7].

In swimming, both for training and competition, the selection of a wetsuit should not be only determined by the textile properties [6] but also considering the comfort, frequency of use and utilization in daily training. The comfort perception is usually assessed using ratings of perceived exertion [8] and is related to the ease of performing the swimming technical movements [9–11]. For instance, a swimmer's greater upper limb muscle mass (compared to triathletes) might be a reason for the popular use of sleeveless long wetsuits in that specific population [9,10]. Meanwhile, it was observed that the fastest swimming performances are related to the use of full-body and sleeveless long wetsuits [10]. Hence, the specific effects of wearing a wetsuit by open water swimmers and triathletes should be considered through the assessment of the possible swimming performance enhancements.

The impact of the wetsuit use on swimming performance, physiology and biomechanics is related to buoyancy and propelling efficiency increases, as well as to drag and energy cost (C) reductions [12,13]. Although using a wetsuit improves front crawl 5–30 min performances [9,14–16], it is still a matter of discussion which specific biophysical changes occur when using a wetsuit (in training and competition contexts). Likewise, an updated literature analysis should discern between different wetsuits, competitive levels and open water swimmers vs. triathletes. The purpose of the current systematic review was two-fold: (i) to summarize the effects of wearing different wetsuits in front crawl swimming performance to observe how it changes in different distances and aquatic environments (swimming pool, flume and open water) and (ii) to identify the key physiological- and biomechanical-related variables that sustain the use of a wetsuit in open water swimming events.

## 2. Material and Methods

### *2.1. Search Strategy*

The current systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) [17,18]. The Web of Science, PubMed and Scopus databases as well as the Conference Proceedings of the International Symposium on Biomechanics and Medicine in Swimming were searched, encompassing peer review studies from inception to 25th March 2022. The key terms used to search the appropriate publications were the following: 'swimming' and 'wetsuit', 'swimming' and 'wet suit', 'swimming' and 'wet-suit', 'swimming' and 'neoprene', 'swimming' and 'thermal swimsuit' and 'swimming' and 'floating swimsuit'. The search strategy was adapted to the four databases and was conducted in titles, abstracts and keywords (Table S1). Moreover, references in relevant reviews and in published eligible studies were screened, and those which were not identified in the initial search were included as additional records (see Figure 1 and Table S1).

### *2.2. Eligibility Criteria*

According to PRISMA guidelines, P.I.C.O.S. was established as follows [17,18]: participants—swimmers, open water swimmers and triathletes; interventions—any methodology that aims to study swimming performance, physiology and biomechanics; comparisons—any wetsuit type and swimsuit; outcomes—performance, physiology and biomechanics variables related to the wetsuit use in swimming; and study design—cross-sectional and/or longitudinal studies. Inclusion criteria were defined as follows: (i) studies assessing front crawl swimming performance while wearing a wetsuit in swimmers and/or triathletes, (ii) studies conducted in 25 or 50 m swimming pools, swimming flume and open water environment (lake, river, water channel or sea) at any water temperature and (iii) studies where the used wetsuits were full body and long or short sleeveless. Exclusion criteria were defined as follows: (i) review studies (qualitative and systematic reviews and meta-analysis), (ii) conference proceedings, with the exception of the Proceedings of the International Symposium on Biomechanics and Medicine in Swimming peer review studies, (iii) studies that evaluated the effects of wearing a wetsuit in water immersions or in the subsequent cycling or running triathlon efforts and (iv) studies that used wetsuits in other exercise modes or fields (non-swimming or triathlon).

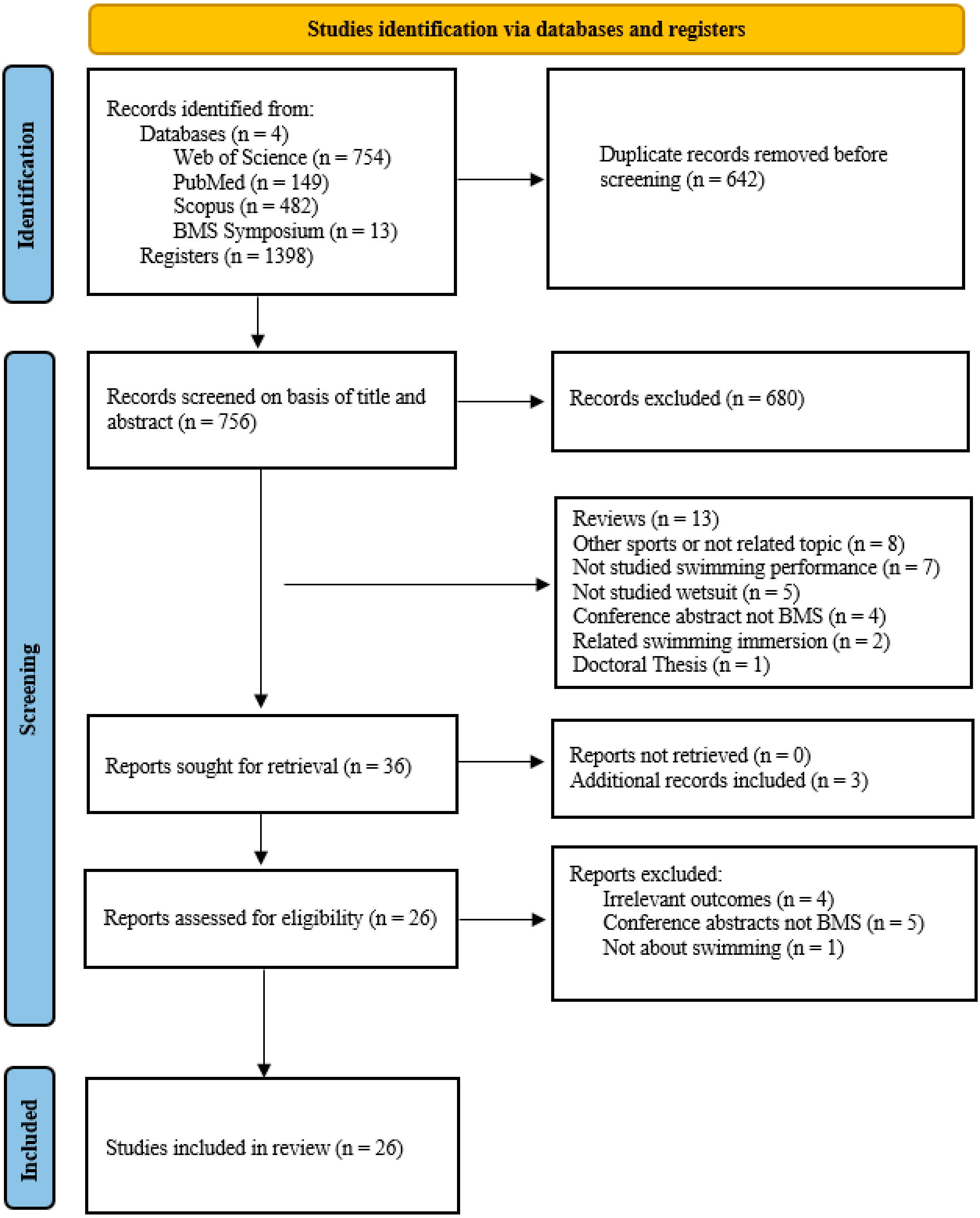


**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) flow diagram of the selected studies. Proceedings of the International Symposium Biomechanics and Medicine in Swimming (BMS).

### 2.3. Study Selection

The review process was conducted by two independent researchers in two different stages. During the first stage, duplicate records were identified and removed from those obtained in the initial search, with titles and abstracts being screened afterwards. The above-referred eligibility criteria were applied by the two researchers and disagreements were discussed until consensus was reached. During the second stage, the same procedure was conducted after screening the remaining full-text records for the final decision about inclusion or exclusion.

### 2.4. Data Extraction

The extraction process was conducted by one researcher and then checked by the second expert. The items extracted were defined as follows: (i) study reference, (ii) sample characteristics (age, gender, swimming level and swimmer specializations—open water swimmer or triathlete), (iii) procedures, (iv) swimming and water temperature, (v) wetsuit type used and (vi) performance, physiological and biomechanical outcomes (Table 1). The studies that compared two vs. three wetsuit types and open water swimmers vs. triathletes were also identified. Disagreements regarding the data extracted were solved in a consensus meeting.

**Table 1.** General characteristics of studies examining age, swimming level, performance assessment, aquatic environment, water temperature and wetsuit information.

| Authors (Year) | N (Mean Age ± SD) Swimming Level | Performance Assessment | Aquatic Environment Water Temperature | Wetsuit Type Thickness |
|---|---|---|---|---|
| Parsons et al. (1986) [1] | 16 triathletes (14 males, 2 females (from 20 to over 50 years old)); beginners and elite | 2 × 30 min swimming with sleeveless long wetsuit and swimsuit | 66 yard (60.35 m) swimming pool 18 °C | Sleeveless long |
| Trappe et al. (1996) [7] | 5 male swimmers (26.1 ± 1.3 years old) | 4 × 5 min swims at 0.90, 1.05, 1.18 ± 0.01 and 1.31 ± 0.02 m· $s^{-1}$ with full-body, sleeveless long and short wetsuit and swimsuit | Swimming flume 26.5 ± 1 °C | Full-body, sleeveless long and short Quintana Roo® 3–4 mm trunk, upper and lower limbs |
| Nicolau, Kozusko and Bishop (2001) [8] | 9 female swimmers (19.6 ± 1.7 years old); university swim team | 3 × 800 m with full-body wetsuit, sleeveless long wetsuit and swimsuit | 50 m swimming pool 27 °C | Full-body and sleeveless long wetsuits Ironman® 5 mm trunk (2–3 mm in the back), 3 mm upper lower limbs |
| Chatard et al. (1995) [9] | 8 swimmers (21 ± 3.1 years old) and 8 triathletes (21 ± 1.5 years old); international | 400 m with wetsuit and swimsuit | 50 m swimming pool 26–26.50 °C | Full-body Aqua Man® 5 mm trunk and 3 mm upper and lower limbs |
| Perrier and Monteil (2001) [10] | 8 swimmers (23 ± 6 years old); regional 8 triathletes (23 ± 4 years old); national | 3 × 400 m maximal with full-body wetsuit, sleeveless long wetsuit and swimsuit | 25 m swimming pool 26 °C | Full-body and sleeveless long Aquaman® 5 mm trunk and lower limbs and 3 mm in upper limbs |
| Toussaint et al. (1989) [12] | 12 swimmers and triathletes (8 males and 4 females) (26.4 ± 4.12 years old) | 10 × 23 m at constant velocity (from 1.00–1.80 m· $s^{-1}$) and 23 m with wetsuit and swimsuit at 1.10, 1.25 and 1.50 m $s^{-1}$ | 25 m swimming pool 26 °C | Sleeveless long wetsuit Aquaman® |

**Table 1.** *Cont.*

| Authors (Year) | N (Mean Age ± SD) Swimming Level | Performance Assessment | Aquatic Environment Water Temperature | Wetsuit Type Thickness |
|---|---|---|---|---|
| Cordain and Kopriva (1991) [14] | 14 female swimmers (19.9 ± 0.9 years old) | 400 m and 1500 m with wetsuit and swimsuit | 25 yard (22.86 m) swimming pool 26–28 °C | Full-body and sleeveless long Scott Tinley 3 mm |
| De Lucas et al. (2000) [15] | 12 males (20.7 ± 4.4 years old) and 7 females (22.0 ± 3.1 years old), from which 11 were regional swimmers and 8 national triathletes | 1500 m maximal 3 × 200 m incremental 30 m maximal with wetsuit and swimsuit | 25 and 50 m swimming pool 25–26 °C | Full-body, sleeveless long Ironman® 5 mm trunk and 3 mm upper and lower limbs |
| Gay et al. (2020) [16] | 33 open water swimmers and triathletes (13 females (26.7 ± 10.3 years old) and 20 males (26.3 ± 12.8 years old)); regional | 2 × 400 m with wetsuit and swimsuit in the swimming pool and 2 × 400 m with wetsuit and swimsuit in the swimming flume | 25 m swimming pool and swimming flume 27 °C | Personal full-body wetsuit 2.20 ± 0.61, 2.72 ± 0.94 and 2.58 ± 0.81 mm in upper limbs, trunk and lower limbs |
| Zacca et al. (2021) [19] | 3 female swimmers (24, 23 and 27 years old); elite swimmers | 2 × 1000 m (400 m at zone 1, 300 m at zone 2, 200 m at zone 3 and 100 m at zone 4 with 30 s recovery intervals with swimsuit and wetsuit) | 25 m swimming pool 27 °C | Full-body Arena Carbon Triwetsuit 1.50 mm shoulder and upper limbs, 3 mm lower limbs, chest and back and 4 mm core region |
| Hue, Benavente and Chollet (2003) [20] | 12 male triathletes (23.7 ± 3.1 years old); national and international | 800, 100 and 50 m with wetsuit and swimsuit | 25 m swimming pool | Full-body Aqua Man® 5 mm trunk and 3 mm upper and lower limbs |
| Perrier and Monteil (2004) [21] | 8 male triathletes (24.8 ± 3.7 years old); national and international | 2 × 1500 m with wetsuit and swimsuit | 50 m swimming pool 26 °C | Full-body Aquaman® 5 mm trunk and lower limbs, 1.50 mm upper limbs |
| Tomikawa and Nomura (2009) [22] | 8 male triathletes (20 ± 1 years old) and 4 female triathletes (21 ± 3 years old) (total (20 ± 1 years old)); national and international | Incremental with wetsuit and swimsuit (competitive swimsuit) in swimming flume, 2 × 25 m sprints with wetsuit and swimsuit and 400 m with wetsuit and swimsuit | Swimming flume and 25 m swimming pool 25.7–27.7 °C | Full-body custom-made for each participant 5 mm trunk, 2–3 mm for upper and lower limbs |
| Tomikawa et al. (2003) [23] | 8 male triathletes (19.6 ± 1.8 years old); national and international | Incremental with wetsuit and swimsuit in swimming flume 400 m with wetsuit and swimsuit | Swimming flume and 25 m swimming pool | Full-body custom-made for each participant |
| Tomikawa, Shimoyama and Nomura (2008) [24] | 9 male triathletes (21.7 ± 3.5 years old) and 4 female triathletes (21.8 ± 1.0 years old) (total 21.7 ± 2.9 years old); national and international | Incremental with wetsuit and competitive swimsuit 2 × 5 min with wetsuit and swimsuit (60 and 80% velocity at maximal oxygen consumption) | Swimming flume | Full-body custom-made for each participant 5 mm trunk, 2–3 mm for upper and lower limbs |
| Lowden, McKenzie and Ridge (1992) [25] | 12 male triathletes (28.6 ± 6.4 years old); international and club competitors | 1500 m maximal with racing swimsuit and sleeveless long wetsuit | 50 and 25 m swimming pool 17.00 ± 1.14, 21.30 ± 0.84 and 29.50 ± 0.23 °C | Sleeveless long wetsuit Shinklow™ 2 mm trunk and lower limbs |
| Perrier and Monteil (2002) [26] | 23 swimmers (23 ± 4.8 years old); regional and national | 3 × 400 m with wetsuit, sleeveless long and swimsuit | 25 m swimming pool 26 °C | Full-body and sleeveless long Aquaman® 5 mm trunk, upper and lower limbs |
| Hatteau et al. (2007) [27] | 7 male triathletes (21 ± 4 years old); national | 3 × 400 m maximal with swimsuit, wetsuit and tri-function suit | 25 m swimming pool 27 °C | Full-body Orca® 5 mm trunk, upper and lower limbs |

**Table 1.** *Cont.*

| Authors (Year) | N (Mean Age ± SD) Swimming Level | Performance Assessment | Aquatic Environment Water Temperature | Wetsuit Type Thickness |
|---|---|---|---|---|
| Gay et al. (2021) [28] | 17 male and female master swimmers (32.4 ± 14.7 years old); regional swimmers | 400 m with swimsuit at 26 °C and 2 × 400 m with swim and wetsuit at 18 °C | Swimming flume at 26 and 18 °C | Personal full-body wetsuit 2.24 ± 0.89, 2.87 ± 1.18 and 2.64 ± 1.07 mm of upper limbs, trunk and lower limbs |
| Yamamoto et al. (1999) [29] | 8 swimmers (21 ± 1 years old); beginners | 5 × 7 min in the swimming flume at constant velocity (0.40, 0.60, 0.80, 1.00 and 1.10 $m \cdot s^{-1}$) with wetsuit and swimsuit 2 × 400 m maximal in 25 m swimming pool with wetsuit and swimsuit | 25 m swimming pool and swimming flume 30 °C | Floating swimsuit (wetsuit) |
| Santos, Bento and Rodacki (2011) [30] | 8 male swimmers and 12 male triathletes (22 ± 6.6 years old); amateur | 4 × 400 m (2 maximal and 2 submaximal, both with wetsuit and swimsuit) | 25 m swimming pool 29 °C | Full-body wetsuit Mormaii 1.50 mm trunk, upper and lower limbs |
| Trappe et al. (1995) [31] | 9 swimmers and triathletes (7 males and 2 females) (31.8 ± 4.1 years old) | 30 m with wetsuit and swimsuit (competitive swimsuit) | 25 yard (22.86 m) swimming pool 20.08 ± 0.03, 22.73 ± 0.09 and 25.59 ± 0.05 °C | Sleeveless long wetsuit Quintana Roo® 3 mm trunk and 4 mm lower limbs |
| Rois et al. (2021) [32] | 10 master swimmers and triathletes (33 ± 7.5 years old); amateur competitive swimmers | 200 and 400 m in 25 m swimming pool and 2 × 75 min at constant velocity with wetsuit and swimsuit in the swimming flume | 25 m swimming pool and swimming flume (25.21 ± 0.29 °C) | Full-body Zone3 2 mm upper lower limbs and trunk |
| Pavlik, Pupis and Pavlovic (2015) [33] | 4 students | 2 × 100 m maximal with wetsuit and swimsuit (one month difference between the two) | 25 m swimming pool 26 °C | Full-body Aquaspare 4 mm trunk, upper and lower limbs |
| Nicolaidis, Sousa and Knechtle (2018) [34] | 1.130 open water ultra-distance swimmers (180 females (35.9 ± 11.9 years old) and 950 males (40.0 ± 10.2 years old)) | 14.3 km of the 'Strait of Gibraltar' since 1950–2018 | Open water environment | Personal wetsuit |
| Ulsamer et al. (2014) [35] | 300 swimmers in the 26.4 km race 284 swimmers in the 3.8 km race | Analyze the use of wetsuit vs. swimsuit in the participants of the 'Marathon Swim' and 'LOST-Race', 26.40 and 3.80 km, respectively | Open water environment | Personal wetsuit |

### 2.5. Quality Assessment

The quality assessment was conducted using the Joanna Briggs Institute Critical Appraisal Tool for Systematic Reviews [36]. This is a tool specifically designed to assess the quality of cross-sectional studies. It gathers eight items related to sample characteristics, methods and outcomes [37,38]. The possible answers to each question were 'yes', 'no' or 'not applicable', and studies were considered as high (≥0.75) or low (<0.75) quality when the final score was obtained [39]. To provide an overview of how the included literature rate each criterion, a summary classification was calculated by dividing the number of positively scored by the total number of included studies. Two independent reviewers conducted this process and disagreements were discussed until consensus was reached. Inter-rater reliability for the initial agreement between researchers was assessed using Cohen's Kappa coefficient statistical analysis with the following criteria: < 0.00 poor; 0.00–0.20 slight; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 substantial and 0.81–1.00 almost perfect [40].

## 3. Results

### 3.1. Study Identification

From the initial search, 1398 studies were identified in the four databases and, after the duplicates were removed, 756 studies remained for the identification phase. Subsequently, 36 records were included after the screening (based on the title and abstract) and a total of 23 studies were finally included in the current systematic review. We may point out that three additional records were added at the discretion of the authors because, even if not included on the database, they fit within the background of the current systematic review. In the final stage, 26 studies were included for eligibility (the study selection process is described in Figure 1).

### 3.2. Quality Assessment

The agreement between both researchers was categorized as substantial (0.61) [40]. From the 26 studies included, 39 and 61% were categorized as high and low quality (respectively) [39]. The agreement between the researchers in the assessment of studies is displayed as Supplementary Material in Table S2.

### 3.3. Sample Characteristics

The current study contains 26 research papers published between 1986–2021 (Table 1) from which 18 [7–10,12,14–16,19,26,28–35] and 17 [1,9,10,12,15,16,20–25,27,30–32,34] included swimmers and triathletes (respectively). Participants' mean age ranged from 13→50 years old, particularly > 18 years (n = 24) [1,7–10,12,14–16,19–32,34], <18 years (n = 11) [8–10,14–16,23,26–28,30] and > 50 years (n = 1) [1], with one study not presenting any age-related information [33]. Regarding the swimming proficiency, participants were from elite (n = 2) [1,19], international (n = 8) [1,9,20–25], national (n = 11) [1,10,14,15,20–24,26,27], regional (n = 6) [1,10,15,16,26,28], beginner (n = 1) [29], club (n = 1) [25], amateur (n = 3) [30–32] and student (n = 2) [8,33] levels, with four studies not presenting detailed information on the topic [7,12,34,35].

The included studies used full-body (n = 18) [7–10,14–16,19–21,23,24,26–28,30,32,33], sleeveless long (n = 10) [1,7,8,10,12,14,15,25,26,31] and sleeveless short (n = 1) [7] wetsuits, with three papers not giving any information about suit typology [29,34,35]. The wetsuit details and thickness are displayed in Table 2 and a summary of the wetsuits related to the sample can be observed in the Supplementary Material (Table S3). The experimental set-ups of the studies took place in 25 m (n = 17, two in 25 yards) [10,12,14–16,19,20,22,23,25–27,29–33] and 50 m swimming pools (n = 6, one in 50 yards) [1,8,9,15,21,25], in swimming flumes (n = 7) [7,16,22–24,28,29] and in natural aquatic environments (n = 2) [34,35]. From the 26 included studies, 14 presented a combination of physiological and biomechanical data and 17 and 22 focused on physiological or biomechanical variables (respectively). The water temperature ranged from 17–30 °C [25,29].

### 3.4. Wetsuit Use and Physiological Reports

The studies that reported physiological data are shown in Table 3. Regarding oxygen consumption ($\dot{V}O_2$), lower values were determined for the following: (i) in the 400 m when using a full-body wetsuit vs. swimsuit [9]; (ii) at different velocities (0.90–1.31 $m \cdot s^{-1}$) when comparing full-body vs. sleeveless long and short wetsuits [7]; (iii) at 0.40 and 0.60 $m \cdot s^{-1}$ with wetsuit vs. swimsuit, but values were similar when swimming at 1.00 and 1.10 $m \cdot s^{-1}$ [29] and (iv) concurrently with lower values of ventilation at 400 m with the use of a full-body wetsuit vs. swimsuit in a swimming flume [28].

**Table 2.** Wetsuits details and thicknesses.

| Wetsuit Type | Upper Limbs Thickness (mm) | Trunk Thickness (mm) | Lower Limbs Thickness (mm) |
|---|---|---|---|
| Sleeveless long [1] | NR | NR | NR |
| Quintana Roo® [7] | 3–4 | 3–4 | 3–4 |
| Ironman® [8] | 3 | 5 (2–3 in the back) | 3 |
| Aqua Man® [9,10,20,21,26] | 3 [9,10,20], 1.50 [21], 5 [26] | 5 | 3 [9,20], 5 [10,21,26] |
| Sleeveless long Aqua Man® [12] | NR | NR | NR |
| Scott Tinley [14] | 3 | 3 | 3 |
| Ironman® [15] | 3 | 5 | 3 |
| Personal full body [16,28] | $2.20 \pm 0.61$ [16]<br>$2.24 \pm 0.89$ [28] | $2.72 \pm 0.94$ [16]<br>$2.87 \pm 1.18$ [28] | $2.58 \pm 0.81$ [16]<br>$2.64 \pm 1.07$ [28] |
| Arena Carbon Triwetsuit® [19] | 1.5 | 3 (back and chest)<br>4 (core region) | 3 |
| Full-body custom-made [22,24] | 2–3 | 5 | 2–3 |
| Full-body custom-made [23] | NR | NR | NR |
| Sleeveless long ShinklowTM [25] | 2 | 2 | 2 |
| Orca® [27] | 5 | 5 | 5 |
| Floating swimsuit [29] | NR | NR | NR |
| Mormaii [30] | 1.5 | 1.5 | 1.5 |
| Quintana Roo® [31] | NR | 3 | 4 |
| Zone3® [32] | 2 | 2 | 2 |
| Aquaspare [33] | 4 | 4 | 4 |
| Personal wetsuit [34,35] | NR | NR | NR |
| Mean ± SD | $2.81 \pm 1.12$ | $3.54 \pm 1.24$ | $3.11 \pm 1.00$ |

Not reported (NR) and standard deviation (SD).

**Table 3.** Physiological variables related to the improvement in different experimental conditions when using a wetsuit.

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Oxygen consumption ($mL \cdot kg^{-1} \cdot min^{-1}$ $/l/min^{-1}$) | NR | NR | Higher with full-body wetsuit vs. swimsuit in swimmers [9] * Equal with full-body wetsuit and swimsuit in triathletes [9] 47.70 ± 11.80 at 26 °C with swimsuit, 44.70 ± 8.40 at 18 °C with swimsuit and 39.10 ± 8.30 at 18 °C with full-body wetsuit [28] * | NR | 59.80 ± 5.00 with full-body wetsuit, 58.70 ± 3.60 with swimsuit [22] 3.83 ± 0.24 with swimsuit, 4.00 ± 0.50 with full-body wetsuit [23] 3.33 ± 0.60 with swimsuit, 3.00 ± 0.60 with full-body wetsuit [24] | 2.75 ± 0.21 with swimsuit, 2.72 ± 0.23 with full-body wetsuit at 20.1 °C [31] 2.96 ± 0.24 with swimsuit, 2.95 ± 0.21 with full-body wetsuit at 22.7 °C [31] 2.89 ± 0.22 with swimsuit, 2.84 ± 0.19 with full-body wetsuit at 25.6 °C [31] | NR | At 0.90 $m \cdot s^{-1}$ (1.17 ± 0.06 with swimsuit *, 0.99 ± 0.03 with sleeveless short *, 0.88 ± 0.06 with sleeveless long and 0.79 ± 0.08 with full body) [7] At 1.05 $m \cdot s^{-1}$ (1.50 ± 0.06 with swimsuit *, 1.25 ± 0.08 with sleeveless short *, 1.17 ± 0.09 with sleeveless long and 0.96 ± 0.10 with full body) [7] At 1.18 $m \cdot s^{-1}$ (1.85 ± 0.09 with swimsuit *, 1.55 ± 0.09 with sleeveless short *, 1.47 ± 0.07 with sleeveless long and 1.24 ± 0.16 with full body) [7] At 1.31 $m \cdot s^{-1}$ (2.63 ± 0.10 with swimsuit *, 2.19 ± 0.12 with sleeveless short *, 2.00 ± 0.14 with sleeveless long and 1.81 ± 0.18 with full body) [7] | Lower with wetsuit vs. swimsuit at 0.40, 0.60 and 0.80 $m \cdot s^{-1}$ Equal with wetsuit vs. swimsuit at 1.00 and 1.10 $m \cdot s^{-1}$ [29] * | NR |
| Velocity at maximal oxygen consumption ($m \cdot s^{-1}$) | NR | NR | NR | NR | 1.24 ± 0.07 with full-body wetsuit, 1.17 ± 0.08 with swimsuit [22] * | NR | NR | NR | NR | NR |

**Table 3.** *Cont.*

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Ventilation ($l/min^{-1}$) | NR | NR | 129.60 ± 31.10 at 26 °C with swimsuit, 119.70 ± 32.70 at 18 °C with swimsuit and 101.00 ± 26.70 at 18 °C with full-body wetsuit [28] * | NR | NR | NR | NR | At 0.90 m· $s^{-1}$ (41.30 ± 3.42 with swimsuit *, 36.40 ± 2.90 with sleeveless short *, 33.80 ± 3.47 with sleeveless long and 31.50 ± 2.49 with full body) [7] At 1.05 m· $s^{-1}$ (48.60 ± 3.28 with swimsuit *, 41.20 ± 3.47 with sleeveless short *, 39.80 ± 3.28 with sleeveless long and 36.90 ± 3.16 with full body) [7] At 1.18 m· $s^{-1}$ (59.50 ± 4.30 with swimsuit *, 50.40 ± 3.48 with sleeveless short *, 47.30 ± 3.04 with sleeveless long and 45.10 ± 4.46 with full body) [7] At 1.31 m· $s^{-1}$ (78.80 ± 4.76 with swimsuit *, 66.20 ± 4.68 with sleeveless short *, 61.90 ± 4.58 with sleeveless long and 60.30 ± 5.81 with full body) [7] | NR | NR |

**Table 3.** *Cont.*

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Peak blood lactate concentrations (mmol·l$^{-1}$) | NR | NR | Higher with full-body wetsuit vs. swimsuit in swimmers [9] * Equal with full-body wetsuit and swimsuit in triathletes [9] 8.05 ± 2.55 with full-body wetsuit and 8.89 ± 2.86 with swimsuit in swimming pool [16] 5.82 ± 3.23 with full-body wetsuit and 5.94 ± 2.99 with swimsuit in swimming flume [16] 8.80 ± 2.20 with swimsuit, 8.80 ± 2.79 with full-body wetsuit (maximal) [30] 5.30 ± 1.65 with swimsuit, 3.80 ± 1.21 with full-body wetsuit (submaximal) [30] * 9.20 ± 1.30 with full-body wetsuit, 8.00 ± 1.00 with swimsuit [22] * 8.80 ± 1.10 with swimsuit, 10.10 ± 1.60 with full-body wetsuit [23] * 10.25 ± 3.45 at 26 °C with swimsuit, 7.99 ± 4.38 at 18 °C with swimsuit, 5.21 ± 2.65 at 18 °C with full-body wetsuit [38] * | NR | 7.60 ± 1.50 with full-body wetsuit, 7.10 ± 1.40 with swimsuit [22] 8.30 ± 2.00 with swimsuit, 8.60 ± 2.30 with full-body wetsuit [23] 7.21 ± 1.48 with swimsuit, 7.36 ± 1.57 with full-body wetsuit [24] | 7.15 ± 0.55 with swimsuit, 6.57 ± 0.73 with sleeveless long wetsuit at 20.1 °C [31] 7.21 ± 0.94 with swimsuit, 6.18 ± 0.76 with sleeveless long wetsuit at 22.7 °C [31] 6.50 ± 0.70 with swimsuit, 5.55 ± 0.69 with sleeveless long wetsuit at 25.6 °C [31] | 2.18 ± 0.59 with full-body wetsuit, 2.46 ± 0.88 with swimsuit at 60% velocity at maximal oxygen consumption [24] 4.70 ± 1.50 with full-body wetsuit, 4.31 ± 1.38 with swimsuit at 80% velocity at maximal oxygen consumption [24] | NR | NR | Similar between full-body wetsuit and swimsuit [32] |

**Table 3.** *Cont.*

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Borg rating of perceived exertion (0–10/6–20 scales) | NR | Equal between full-body and sleeveless long wetsuits [8] | 7.91 ± 1.23 with full-body wetsuit and 7.88 ± 0.86 with swimsuit in swimming pool [16] 6.36 ± 1.66 with full-body wetsuit and 6.33 ± 1.68 with swimsuit in swimming flume [16] 17.50 ± 2.00 with swimsuit, 17.30 ± 1.70 with full-body wetsuit and 17.00 ± 2.20 with sleeveless long wetsuit [26] 17.10 ± 1.71 with swimsuit, 17.10 ± 1.59 with full-body wetsuit (maximal) [30] 12.20 ± 2.12 with swimsuit, 10.75 ± 1.88 with full-body wetsuit (submaximal) [30] * 17.40 ± 1.20 with swimsuit, 17.60 ± 0.70 with full-body wetsuit [23] 7.12 ± 1.32 at 26 °C with swimsuit, 5.35 ± 1.73 at 18 °C with swimsuit and 6.00 ± 2.09 at 18 °C with full-body wetsuit [28] * | NR | NR | Similar with sleeveless long wetsuit and swimsuit at 20.1, 22.7 and 25.6 °C [31] | 12.00 ± 1.00 with full-body wetsuit, 12.00 ± 1.00 with swimsuit at 60% velocity at maximal oxygen consumption [24] 15.00 ± 2.00 with full-body wetsuit, 15.00 ± 1.00 with swimsuit at 80% velocity at maximal oxygen consumption [24] | At 0.90 m $s^{-1}$ (7.00 ± 0.40 with swimsuit, 6.60 ± 0.20 with sleeveless short, 6.20 ± 0.20 with sleeveless long and 6.60 ± 0.20 with full body) [7] At 1.05 m· $s^{-1}$ (9.60 ± 0.40 with swimsuit, 8.40 ± 0.20 with sleeveless short, 7.80 ± 0.30 with sleeveless long and 8.60 ± 0.60 with full body) [7] At 1.18 m· $s^{-1}$ (11.20 ± 0.30 with swimsuit, 10.40 ± 0.20 with sleeveless short, 10.00 ± 0.50 with sleeveless long and 10.20 ± 0.70 with full body) [7] At 1.31 m· $s^{-1}$ (13.80 ± 0.30 with swimsuit *, 12.60 ± 0.20 with sleeveless short, 11.80 ± 0.30 with sleeveless long and 12.20 ± 0.80 with full body) [7] | NR | Similar between full-body wetsuit and swimsuit [32] |

**Table 3.** *Cont.*

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Maximal heart rate (beats·min$^{-1}$) | Higher at 21.3 vs. 17 °C [25] * Higher at 29.5 vs. 17 °C [25] * Higher with sleeveless long wetsuit vs. Lycra suit [25] * | Equal between full-body wetsuit, sleeveless long wetsuits and swimsuit [8] | 180 ± 12 with full-body wetsuit and 176 ± 14 with swimsuit in swimming pool [16] 167 ± 16 with full-body wetsuit and 168 ± 15 with swimsuit in swimming flume [16] 177 ± 11 with swimsuit, 179 ± 8 with full-body wetsuit and 177 ± 10 with sleeveless long wetsuit [26] 172 ± 11 with swimsuit, 169 ± 17 with full-body wetsuit (maximal) [30] 149 ± 18 with swimsuit and 134 ± 19 with full-body wetsuit (submaximal) [30] * Lower with wetsuit vs. swimsuit [29] * 182 ± 19 at 26 °C with swimsuit, 183 ± 19 at 18 °C with swimsuit and 154 ± 12 at 18 °C with full-body wetsuit [28] * | 2 subjects higher with full-body wetsuit and 2 subject lower with full-body wetsuit [33] | NR | Similar with sleeveless long wetsuit and swimsuit at 20.1, 22.7 and 25.6 °C [31] | NR | At 0.90 m· s$^{-1}$ (95 ± 3 with swimsuit, 97 ± 5 with sleeveless short, 92 ± 4 with sleeveless long and 89 ± 3 with full body) [7] At 1.05 m· s$^{-1}$ (107 ± 2 with swimsuit, 104 ± 3 with sleeveless short, 103 ± 4 with sleeveless long and 102 ± 2 with full body) [7] At 1.18 m· s$^{-1}$ (121 ± 4 with swimsuit, 116 ± 5 with sleeveless short, 110 ± 3 with sleeveless long and 113 ± 5 with full body) [7] At 1.31 m· s$^{-1}$ (143 ± 4 with swimsuit *, 133 ± 3 with sleeveless short, 130 ± 2 with sleeveless long and 127 ± 5 with full body) [7] | Lower with wetsuit vs. swimsuit at 0.40, 0.60 and 0.80 m·s$^{-1}$, equal with wetsuit vs. swimsuit at 1.00 and 1.10 m·s$^{-1}$ [29] | Lower with full-body wetsuit vs. swimsuit [32] * |

**Table 3.** *Cont.*

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Respiratory exchange ratio | NR | NR | 1.20 ± 0.20 at 26 °C with swimsuit, 1.30 ± 0.30 at 18 °C with swimsuit and 1.20 ± 0.30 at 18 °C with full-body wetsuit [28] | NR | NR | NR | NR | At 0.90 m $s^{-1}$ (0.87 ± 0.04 with swimsuit, 0.92 ± 0.02 with sleeveless short, 0.89 ± 0.03 with sleeveless long and 0.84 ± 0.04 with full body) [7] At 1.05 m· $s^{-1}$ (0.88 ± 0.03 with swimsuit, 0.87 ± 0.03 with sleeveless short, 0.88 ± 0.03 with sleeveless long and 0.84 ± 0.03 with full body) [7] At 1.18 m· $s^{-1}$ (0.92 ± 0.03 with swimsuit, 0.89 ± 0.04 with sleeveless short, 0.91 ± 0.03 with sleeveless long and 0.87 ± 0.03 with full body) [7] At 1.31 m· $s^{-1}$ (0.97 ± 0.02 with swimsuit, 0.95 ± 0.03 with sleeveless short, 0.95 ± 0.02 with sleeveless long and 0.94 ± 0.04 with full body) [7] | NR | NR |
| Energy cost (kJ·$m^{-1}$/ mL·$kg^{-1}$·$min^{-1}$) | NR | NR | Equal with swimsuit vs. wetsuit in swimmers [9] Lower with wetsuit vs. swimsuit in triathletes [9] * 0.93 ± 0.26 at 26 °C with swimsuit, 0.92 ± 0.19 at 18 °C with swimsuit and 0.79 ± 0.15 at 18 °C with full-body wetsuit [28] * | NR | 2 swimmers reduced energy cost with full-body wetsuit vs. swimsuit in 4 swimming intensities [19] | NR | 41.00 ± 9.00 with full-body wetsuit, 48.00 ± 12.00 with swimsuit (14.4%) at 60% velocity at maximal oxygen consumption [24] * 47.00 ± 9.00 with full-body wetsuit, 51.00 ± 10.00 with swimsuit (7.5%) at 80% velocity at maximal oxygen consumption [24] * | NR | NR | NR |

**Table 3.** *Cont.*

| | Distance | | | | | Time | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Total energy expenditure (kJ/kW) | NR | NR | 370.44 ± 105.88 at 26 °C with swimsuit, 366.34 ± 74.16 at 18 °C with swimsuit and 315.02 ± 60.71 at 18 °C with full-body wetsuit [28] * | NR | Lower with full-body wetsuit vs. swimsuit in 4 swimming intensities [19] | NR | NR | NR | NR | NR |
| Core temperature (°C) | Lower at 17 vs. 29.5 °C with swimsuit vs. sleeveless long wetsuit [25] * Lower at 21.3 vs. 29.5 °C with Lycra suit vs. sleeveless long wetsuit [25] * Lower at 17 vs. 21.3 °C with swimsuit vs. Lycra suit [25] * | NR | NR | NR | NR | 38.01 ± 0.28 with swimsuit, 38.17 ± 0.23 with sleeveless long wetsuit At 20.1 °C [31]; 38.04 ± 0.26 with swimsuit, 38.65 ± 0.17 with sleeveless long wetsuit at 22.7 °C [31] *; 38.68 ± 0.21 with swimsuit, 38.67 ± 0.21 with sleeveless long wetsuit at 25.6 °C [31] * | NR | NR | NR | Higher with full-body wetsuit vs. swimsuit at the end of exercise [32] * |
| Trunk temperature (°C) | Lower at 17 vs. 29.5 °C with swimsuit vs. sleeveless long wetsuit [25] * Lower at 21.3 vs. 29.5 °C with Lycra suit vs. sleeveless long wetsuit [25] * Lower at 17 vs. 21.3 °C with swimsuit vs. Lycra suit [25] * | NR | NR | NR | NR | 20.58 with swimsuit, 24.96 ± 0.28 with sleeveless long wetsuit at 20.1 °C [31] *; 23.17 with swimsuit, 26.92 ± 0.51 with sleeveless long wetsuit at 22.7 °C [31] *; 26.08 with swimsuit, 29.12 ± 0.44 with sleeveless long wetsuit at 25.6 °C [31] * | NR | NR | NR | NR |

**Table 3.** *Cont.*

| | Distance | | | | Time | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **Incremental** | **30 min** | **2 × 5 min** | **4 × 5 min in Swimming Flume** | **5 × 7 min in Swimming Flume** | **75 min in Swimming Flume** |
| Rectal temperature (°C) | Higher at 29.5 vs. 21.3 °C with sleeveless long wetsuit vs. Lycra suit [25] * Higher at 21.3 vs. 17 °C with Lycra suit vs. swimsuit [25] * Higher at 29.5 vs. 17 °C with sleeveless long wetsuit vs. swimsuit [25] * | NR | NR | NR | NR | NR | NR | NR | NR | NR |
| Skin temperature (°C) | NR | NR | NR | NR | NR | NR | NR | NR | NR | Constant with full-body wetsuit and swimsuit [32] |

Not reported (NR). * Differences between conditions.

Studies showed contradictory results regarding peak blood lactate concentrations ([La$^-$]). Lower values were shown in distances of 2 × 25, 2 × 75 and 400 m [9,22,28,30,32] and higher values in 2 × 25 and 400 m [22]. The existent data were displayed for full-body wetsuit vs. swimsuit. Regarding heart rate (HR), lower values were observed when swimming 400 m wearing a full-body wetsuit vs. swimsuit [28–30] and higher values appeared during 1500 m using a sleeveless long wetsuit vs. swimsuit [25]. In addition, when swimming 400 m in the swimming flume, C was lower while wearing a full-body wetsuit vs. swimsuit [9,24], and simultaneously lower energy expenditure when using a full-body wetsuit vs. swimsuit [28]. Finally, during a 30 min swim in water temperatures ranging from 17–29.5°, trunk and rectal temperatures showed higher values with the sleeveless long wetsuit vs. swimsuit [25,31], and after swimming 75 min a higher core temperature with the use of a full-body wetsuit vs. swimsuit was observed [32].

### *3.5. Wetsuit Use and Biomechanical Reports*

Results showed a performance improvement when comparing full-body wetsuits vs. swimsuit and sleeveless long/short wetsuits. Performance enhancement ranged from 3.2–12.9% in 25–1500 m, incremental tests, 5 and 30 min, and open water swimming performances. On the other hand, the use of a sleeveless long wetsuit allowed an enhancement in 400 and 800 m performance compared to the full-body wetsuit and swimsuit (Table 4) [8,10,26]. Regarding biomechanical variables, stroke rate (SR) [22–24], stroke length (SL) [16,20–23,27,28,30] and stroke index (SI) were higher with a full-body wetsuit vs. swimsuit [16,20,21,28,30], with SR and SL being also higher while using a sleeveless long wetsuit vs. swimsuit [31]. No differences were found between suits in propelling efficiency while swimming 400 and 25 m in a swimming flume [19,28]. In addition, one study reported lower active drag and drag–swimming velocity relationship while using sleeveless long vs. full-body wetsuits [12].

### *3.6. Wetsuit Use Effect in Swimmers and Triathletes*

From the total sample, only two studies compared swimmers vs. triathletes and reported physiological and biomechanical variables (Tables 5 and 6) [9,10]. Swimmers performed lower times in 400 m with full-body wetsuits than triathletes [9]. In addition, swimmers' performance was lower while using a full-body wetsuit vs. swimsuit and triathletes were faster with a full-body wetsuit vs. swimsuit. However, no differences were found between swimmers and triathletes in Borg rating of perceived exertion, peak [La$^-$] and SR [9]. In addition, results showed higher values in speed, SR and SL with sleeveless long wetsuits for swimmers and triathletes compared to full-body wetsuits and swimsuits [10] (Table 6).

**Table 4.** Biomechanical variables related to the improvement in different experimental conditions when using a wetsuit.

| | Distance | | | | | | Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Time performed/improved with wetsuits (s) | 35.18 s less (3.2% improvement) with full-body and sleeveless long wetsuits vs. swimsuit [14] * 47 s less (3.7% improvement) with full-body and sleeveless long wetsuits vs. swimsuit [15] * 80 s less (6.5% reduction) with full-body wetsuit [21] * 3 min 10 s less (10% improvement) with wetsuit vs. swimsuit [25] * 3 min 25 s less with wetsuit vs. sleeveless long wetsuit [25] * 15 s less with wetsuit vs. Lycra suit [25] * | 22.30 s less with full-body vs. swimsuit, 39.70 s less with sleeveless long vs. swimsuit [8] * | With swimsuit and with full-body wetsuit swimmers were faster than triathletes [9] * 14.92 s less (5% improvement) with full-body and sleeveless long wetsuits vs. swimsuit [14] * 20.08 s less (6% improvement) with full-body wetsuit vs. swimsuit [16] * 37.30 s less (12% improvement) with full-body wetsuit [27] * 21.50 s less with full-body wetsuit vs. swimsuit [26] 25.40 s less with sleeveless long wetsuit vs. swimsuit [26] 1.4% higher with sleeveless long vs. full-body wetsuit [26] 18 s less (6.4% lower) with full-body wetsuit (maximal) vs. swimsuit [30] * 6.9% higher with full-body wetsuit vs. swimsuit [22] * 21.30 s less (6.8% improvement) with swimsuit vs. full-body wetsuit [23] * | 14.75 s less (12.9% improvement) with full-body wetsuit vs. swimsuit [33] * | 4.3% higher with full-body wetsuit vs. swimsuit [22] * | NR | 77.40 s more with full-body wetsuit vs. swimsuit [23] * 5.4% higher with full-body wetsuit vs. swimsuit [24] * | 24.90 lengths more with sleeveless long wetsuit vs. 23.20 with swimsuit (7%) [1] * 188 ± 8.50 m more with sleeveless long wetsuit vs. swimsuit (9.2%) [31] * | 9.4% lower with full-body wetsuit vs. swimsuit at 60% velocity of maximal oxygen consumption [24] * Equal with full-body wetsuit vs. swimsuit and swimsuit at 80% velocity of maximal oxygen consumption [24] | Males 13 min less with personal wetsuit vs. swimsuit [34] * 134.30 min (32.7%) less in men vs. woman both with personal wetsuit in 26.4 km (top 10) [35] * 5.9% faster top 3 men using personal wetsuit vs. top 3 men not using wetsuit in 26.4 km [35] * 6.80 min (13.2%) faster males vs. females (top 10) with personal wetsuit in 3.8 km [35] * 3.80 min (6.5%) faster females with personal wetsuit vs. females with swimsuit (top 10) in 3.8 km [35] * |

**Table 4.** *Cont.*

| | Distance | | | | | | Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Swimming velocity ($m \cdot s^{-1}$) | Higher with full-body and sleeveless long wetsuits vs. swimsuit [15] * 1.17 ± 0.08 with swimsuit 1.21 ± 0.08 with full-body and with sleeveless long wetsuits [15] * 1.26 ± 0.15 with swimsuit and 1.37 ± 0.13 with full-body wetsuit in the first 100 m [21] * 1.15 ± 0.11 with swimsuit and 1.24 ± 0.11 with full-body wetsuit in the last 100 m [21] * | 1.38 ± 0.05 with full-body wetsuit and 1.36 ± 0.03 with swimsuit [20] 1.28 ± 0.06 with swimsuit, 1.31 ± 0.03 with full-body wetsuit and 1.36 ± 0.07 with sleeveless long wetsuit [8] * | 1.24 ± 0.16 with full-body wetsuit and 1.17 ± 0.16 with swimsuit in swimming pool [16] * 1.30 ± 0.09 with full-body wetsuit and 1.16 ± 0.07 with swimsuit [27] * 1.30 ± 0.13 with swimsuit, 1.40 ± 0.13 with full-body wetsuit and 1.42 ± 0.14 with sleeveless long wetsuit [26] 1.36 ± 0.07 with swimsuit, 1.44 ± 0.08 with full-body wetsuit (maximal) [30] * 1.23 ± 0.06 with swimsuit, 1.24 ± 0.06 with full-body wetsuit (submaximal) [30] 1.36 ± 0.09 with full-body wetsuit, 1.27 ± 0.09 with swimsuit [22] * 1.30 ± 0.16 with swimsuit, 1.39 ± 0.14 with full-body wetsuit [23] * 1.23 ± 0.21 at 26 °C with swimsuit, 1.23 ± 0.17 at 18 °C with swimsuit and 1.24 ± 0.21 at 18 °C with full-body wetsuit [28] | 1.63 ± 0.08 with full-body wetsuit and 1.61 ± 0.07 with swimsuit [20] | 1.70 ± 0.09 with full-body wetsuit, 1.63 ± 0.11 with swimsuit [22] * | 1.70 ± 0.08 with full-body wetsuit and 1.66 ± 0.08 with swimsuit [20] | 1.12 ± 0.15 with swimsuit 1.18 ± 0.16 with full-body wetsuit [24] * 2 swimmers increased with full-body wetsuit vs. swimsuit in 4 swimming intensities vs. swimsuit [19] | Higher with full-body and with sleeveless long wetsuits [15] * 1.43 ± 0.14 with swimsuit 1.50 ± 0.12 with full-body and with sleeveless long wetsuits [15] * | NR | NR |

**Table 4.** *Cont.*

| | Distance | | | | | | Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Stroke rate (Hz/strokes·min$^{-1}$) | 35.80 ± 3.20 with swimsuit and 36.70 ± 2.40 with full-body wetsuit in the first 100 m [21] 37.10 ± 2.40 with swimsuit and 38.90 ± 3.30 with full-body wetsuit in the last 100 m [21] * | 35.90 ± 3.70 with full-body wetsuit and 36.40 ± 4.20 with swimsuit [20] | Higher with wetsuit vs. swimsuit in triathletes [9] * Equal with wetsuit vs. swimsuit in swimmers [9] 0.62 ± 0.09 with full-body wetsuit and 0.61 ± 0.07 with swimsuit in swimming pool [16] 0.52 ± 0.07 with full-body wetsuit and 0.52 ± 0.06 with swimsuit in swimming flume [16] 0.46 ± 0.05 with full-body wetsuit and 0.46 ± 0.04 with swimsuit [27] 0.63 ± 0.05 with swimsuit, 0.64 ± 0.05 with full-body wetsuit and 0.63 ± 0.05 with sleeveless long wetsuit [26] 36.4 ± 4.54 with swimsuit, 36.35 ± 4.52 with full-body wetsuit (maximal) [30] 30.65 ± 3.7 with swimsuit, 28.20 ± 3.70 with full-body wetsuit (submaximal) [30] * 34.70 ± 1.70 with full-body wetsuit, 33.90 ± 1.60 with swimsuit [22] * Higher with full-body wetsuit [23] * 0.56 ± 0.08 at 26 °C with swimsuit, 0.55 ± 0.07 at 18 °C with swimsuit and 0.51 ± 0.07 at 18 °C with full-body wetsuit [28] * | 47.20 ± 4.70 with full-body wetsuit and 48.30 ± 4.20 with swimsuit [20] | NR | 51.50 ± 4.20 with full-body wetsuit and 51.90 ± 2.70 with swimsuit [20] | Lower with full-body wetsuit vs. swimsuit [23] Higher with full-body wetsuit in all swimming intensities vs. swimsuit [19] | NR | 4.2% higher with full-body wetsuit vs. swimsuit at 60% velocity of maximal oxygen consumption [24] * 4.4% higher with full-body wetsuit vs. swimsuit at 80% velocity of maximal oxygen consumption [24] * | NR |

**Table 4.** *Cont.*

| | Distance | | | | | | Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Stroke length (m) | 2.12 ± 0.20 with swimsuit and 2.24 ± 0.19 with full-body wetsuit in the first 100 m [21] * 1.87 ± 0.23 with swimsuit and 1.93 ± 0.24 with full-body wetsuit in the last 100 m [21] * | 2.34 ± 0.20 with full-body wetsuit and 2.27 ± 0.20 with swimsuit [20] Equal with full-body and sleeveless long wetsuit vs. swimsuit [8] | 1.84 ± 0.23 with full-body wetsuit and 1.76 ± 0.20 with swimsuit in swimming pool [16] * 2.48 ± 0.45 with full-body wetsuit and 2.30 ± 0.32 with swimsuit in swimming flume [16] * 1.24 ± 0.11 with full-body wetsuit and 1.14 ± 0.11 with swimsuit [27] * 1.93 ± 0.91 with swimsuit, 2.07 ± 0.29 with full-body wetsuit and 2.12 ± 0.23 with sleeveless long wetsuit [26] 2.27 ± 0.26 with swimsuit, 2.39 ± 0.27 with full-body wetsuit (maximal) [30] * 2.46 ± 0.28 with swimsuit, 2.69 ± 0.28 with full-body wetsuit (submaximal) [30] * 2.32 ± 0.21 with full-body wetsuit, 2.27 ± 0.20 with swimsuit [22] * Higher with full-body wetsuit [23] * 2.25 ± 0.43 at 26 °C with swimsuit, 2.28 ± 0.38 at 18 °C with swimsuit and 2.48 ± 0.48 at 18 °C with full-body wetsuit [28] * | 2.09 ± 0.20 with full-body wetsuit and 2.02 ± 0.20 with swimsuit [20] * | NR | 1.99 ± 0.10 with full-body wetsuit and 1.93 ± 0.10 with swimsuit [20] * | Lower with full-body wetsuit vs. swimsuit in all swimming intensities [19] | 2.18 with swimsuit and 2.39 with sleeveless long wetsuit (9.6%) vs. swimsuit [31] * | Equal with full-body wetsuit vs. swimsuit [24] | NR |

**Table 4.** *Cont.*

| | Distance | | | | | | Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Stroke index ($m^2 \cdot s^{-1}$) | 2.69 ± 0.50 with swimsuit and 3.07 ± 0.50 with full-body wetsuit in the first 100 m [21] * 2.16 ± 0.45 with swimsuit and 2.40 ± 0.49 with full-body wetsuit in the last 100 m [21] * | 3.25 ± 0.30 with full-body wetsuit and 3.09 ± 0.40 swimsuit [20] * Equal with full-body and sleeveless long wetsuit vs. swimsuit [8] | 2.10 ± 0.47 with full-body wetsuit and 1.90 ± 0.40 with swimsuit in swimming pool [16] * 3.22 ± 0.91 with full-body wetsuit and 2.78 ± 0.67 with swimsuit in swimming flume [16] * 3.09 ± 0.41 with swimsuit, 3.51 ± 0.41 with full-body wetsuit (maximal) [30] * 3.05 ± 0.41 with swimsuit, 3.34 ± 0.49 with full-body wetsuit (submaximal) [30] * 2.83 ± 1.04 at 26 °C with swimsuit, 2.86 ± 0.84 at 18 °C with swimsuit, 3.15 ± 1.17 at 18 °C with full-body wetsuit [28] * | 3.43 ± 0.40 with full-body wetsuit and 3.26 ± 0.40 with swimsuit [20] * | NR | 3.40 ± 0.30 with full-body wetsuit and 3.21 ± 0.30 with swimsuit [20] * | NR | NR | NR | NR |
| Propelling efficiency (%) | NR | NR | 40 ± 7.5 with full-body wetsuit and 40.6 ± 6.3 with swimsuit in swimming pool [16] 52.4 ± 11.2 with full-body wetsuit and 51.6 ± 11.3 with swimsuit in swimming flume [16] 46.6 ± 8.9 at 26 °C with swimsuit, 45.9 ± 8.4 at 18 °C with swimsuit and 48.9 ± 10.9 with at 18 °C full-body wetsuit [28] | NR | NR | NR | Lower with full-body wetsuit in all swimming intensities vs. swimsuit [19] | NR | NR | NR |

**Table 4.** *Cont.*

| | Distance | | | | | | | Time | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Index of coordination | −17.70 ± 8.00 with swimsuit and −20.60 ± 6.00 with full-body wetsuit in the first 100 m [21] −12.60 ± 8.00 with swimsuit and −18.40 ± 1.00 with full-body wetsuit in the last 100 m [21] | −11.70 ± 3.70 with full-body wetsuit and −9.60 ± 3.80 with swimsuit [20] * | NR | −7.20 ± 3.70 with full-body wetsuit and −5.10 ± 4.40 with swimsuit [20] | NR | −5.70 ± 4.50 with full-body wetsuit and −5.60 ± 5.20 with swimsuit [20] | Higher with full-body wetsuit in all swimming intensities vs. swimsuit [19] | NR | NR | NR |
| Active drag (N) | NR | NR | NR | NR | 79.10 ± 18.10 with full-body wetsuit, 79.40 ± 23.80 with swimsuit [22] 32.90 ± 6.70 with swimsuit, 27.70 ± 6.90 with sleeveless long wetsuit at 1.10 $m{\cdot}s^{-1}$ (16%) [12] *; 48.70 ± 9.50 with swimsuit, 41.80 ± 9.30 with sleeveless long wetsuit at 1.25 $m{\cdot}s^{-1}$ (14%) [12] *; 73.30 ± 13.90 with swimsuit, 64.30 ± 12.90 with sleeveless long wetsuit at 1.50 $m{\cdot}s^{-1}$ (12%) [12] * | NR | NR | 49.02 ± 16.47 with swimsuit 54.24 ± 17.25 with full-body and sleeveless long wetsuits [15] | NR | NR |
| Passive drag (N) | NR | NR | Equal with wetsuit and swimsuit in swimmers and triathletes [9] | NR | 0.34 ± 0.05 with full-body wetsuit, 0.37 ± 0.08 with swimsuit [22] | NR | NR | 0.30 ± 0.07 with swimsuit, 0.30 ± 0.07 with full-body wetsuit and sleeveless long wetsuits [15] | NR | NR |

**Table 4.** *Cont.*

| | Distance | | | | | | Time | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **1500 m** | **800 m** | **400 m** | **100 m** | **25 m (23 m [12])** | **50 m** | **Incremental** | **30 min** | **2 × 5 min** | **Open Water** |
| Maximal power output (W) | NR | NR | NR | NR | 135.60 ± 36.90 with full-body wetsuit, 131.20 ± 46.20 with swimsuit [22] | NR | NR | NR | NR | NR |
| Mechanical power to overcome drag (W) | NR | NR | NR | NR | NR | NR | Lower with full-body wetsuit vs. swimsuit in 4 swimming intensities vs. swimsuit [19] | NR | NR | NR |
| Relation between drag and swimming velocity (N) | NR | NR | NR | NR | 27.20 ± 5.40 with swimsuit, 22.90 ± 5.70 with sleeveless long wetsuit at 1.10 $m \cdot s^{-1}$ [12] *; 31.20 ± 6.10 with swimsuit, 26.80 ± 6.00 with sleeveless long wetsuit at 1.25 $m \cdot s^{-1}$ [12] *; 32.60 ± 6.20 with swimsuit, 28.50 ± 6.10 with sleeveless long wetsuit at 1.50 $m \cdot s^{-1}$ [12] * | NR | NR | NR | NR | NR |

Not reported (NR). * Differences between conditions.

**Table 5.** Physiological variable comparison for swimmers and triathletes.

| | **Swimmers** | **Triathletes** |
|---|---|---|
| **Variables** | **400 m** | **400 m** |
| Maximal oxygen consumption (L·min$^{-1}$) | 5.30 ± 0.40 with swimsuit<br>4.90 ± 0.30 with full-body wetsuit [9] * | No differences [9] |
| Peak blood lactate concentrations (mmol·L$^{-1}$) | 12.30 ± 1.50 with swimsuit<br>10.90 ± 2.10 with full-body wetsuit [9] * | No differences [9] |
| Borg rating of perceived exertion (0–10/6–20 scales) | 17.30 ± 2.00 with swimsuit,<br>17.50 ± 1.60 with full-body wetsuit and 17.10 ± 1.40 with sleeveless long wetsuit [10] | 16.90 ± 1.50 with swimsuit, 17.20 ± 1.10 with full-body wetsuit and 17.60 ± 1.00 with sleeveless long wetsuit [10] |
| Maximal heart rate (beats·min$^{-1}$) | 179 ± 11 with swimsuit,<br>179 ± 9 with full-body wetsuit and 179 ± 10 with sleeveless long wetsuit [10] | 177 ± 12 with swimsuit, 180 ± 8 with full-body wetsuit and 180 ± 9 with sleeveless long wetsuit [10] |
| Energy cost (kJ·m$^{-1}$) | No differences [9] | Lower with full-body wetsuit vs. swimsuit [9] * |

* Differences between conditions.

**Table 6.** Biomechanical variable comparison for swimmers and triathletes.

| | Swimmers | Triathletes |
|---|---|---|
| **Variables** | **400 m** | **400 m** |
| Time performed/improved with wetsuits (s) | 253.90 ± 8.00 with swimsuit<br>252.50 ± 4.50 with full-body wetsuit [9]<br>17.20 s (6.3%) with swimsuit vs. full-body wetsuit [10] *<br>22.90 s (8.5%) with swimsuit vs. sleeveless long wetsuit [10] * | 19 s less with full-body wetsuit, 304.80 ± 30.10 with swimsuit, 285.80 ± 33.90 with full-body wetsuit, 6% faster with full-body wetsuit [9] *<br>23.80 s (8.5%) with swimsuit vs. full-body wetsuit [10] *<br>26.30 s (9.5%) with swimsuit vs. sleeveless long wetsuit [10] * |
| Swimming velocity ($m \cdot s^{-1}$) | 1.38 ± 0.04 with swimsuit,<br>1.46 ± 0.04 with full-body wetsuit and 1.50 ± 0.06 with sleeveless long wetsuit [10] * | 1.32 ± 0.07 with swimsuit,<br>1.43 ± 0.06 with full-body wetsuit and 1.44 ± 0.08 with sleeveless long wetsuit [10] * |
| Stroke rate (Hz) | No differences [9]<br>0.62 ± 0.03 with swimsuit,<br>0.63 ± 0.05 with full-body wetsuit and 0.62 ± 0.03 with sleeveless long wetsuit [10] * | 40.30 ± 1.20 with swimsuit,<br>42.30 ± 1.40 with full-body wetsuit [9] *<br>0.64 ± 0.04 with swimsuit,<br>0.66 ± 0.04 with full-body wetsuit and 0.66 ± 0.03 with sleeveless long wetsuit [10] * |
| Stroke length (m) | 2.01 ± 0.09 with swimsuit,<br>2.14 ± 0.08 with full-body wetsuit and 2.27 ± 0.14 with sleeveless long wetsuit [10] * | 1.88 ± 0.15 with swimsuit,<br>2.04 ± 0.21 with full-body wetsuit and 2.05 ± 0.14 with sleeveless long wetsuit [10] * |
| Passive drag (N) | No differences [9] | Lower with full-body wetsuit vs. swimsuit [9] * |

* Differences between conditions.

## 4. Discussion

Research about wetsuit use in swimming dates back to 1986 [1]. Thus, the aim of the current systematic review was to summarize the effects of wearing different types of wetsuits and swimsuits in front crawl swimming performance and physiological- and biomechanical-related variables. The use of a full-body wetsuit produces an enhancement of 3.2–12.9% in 25–1500 m front crawl swimming performance, swimming incremental tests, 5 and 30 min continuous swimming and open water swimming events. Furthermore, the sleeveless long wetsuit also produces performance advantages in comparison with a full-body wetsuit [8,10,26].

### *4.1. Wetsuit Use on Swimming Performance Related to the Body Cover*

The wetsuit thermal insulation depends on its composition and textile properties, showing higher thicknesses (>4 mm) and presenting better hydrophobic properties than those with lower thicknesses [6]. When more body area is covered by, i.e., full-body wetsuits, the thermal properties are improved [6], also producing greater biomechanical changes [8,10]. The full-body wetsuit produces changes in most of the physiological and biomechanical variables compared to swimsuits such as lower [$La^-$], maximal HR and C and higher SR, SL and SI values. Together, those findings help to justify the performance enhancement when using that type of suit [20,24,27,28,32].

The information about the sleeveless short wetsuit is scarce, with only one study reporting higher values of $\dot{V}O_2$ and ventilation compared to sleeveless long and full-body wetsuits in a swimming flume (four velocities ranged from 0.90–1.31 $m \cdot s^{-1}$) [7]. Due to a sleeveless short wetsuit covering less body area, the advantages arising from buoyancy are minor, leading to a greater drag and higher energy demands than using the other two wetsuits. Additionally, studies showed that the sleeveless long wetsuit benefited the swimmers more than triathletes [8,10], probably due to superior swimming skills in swimmers, as is discussed later [10]. Nevertheless, the sleeveless long wetsuit type is gaining popularity in open water swimming and triathlon competitions due to the comfort provided in the shoulder joint movements [8].

### *4.2. Wetsuit Use and Physiological Reports*

A crucial variable to analyze in open water swimmers and triathletes is $\dot{V}O_{2max}$, since it has been considered a determinant of the maximal aerobic performance capability [41]. Similar $\dot{V}O_{2max}$, values were found for swimmers and triathletes while using full-body wetsuits in 400 m swimming [9], while lower $\dot{V}O_2$ and ventilation values were observed with full-body, sleeveless long and short wetsuits compared to swimsuits when swimming in a swimming flume for 5 [7] and 7 min [29] (Table 3). These results suggest that using three wetsuit types reduces the energy requirements in these trials (i.e., 400 m and 5 and 7 min swims), as cardiorespiratory responses are small. Furthermore, the swimming velocity reached when wearing a full-body wetsuit was higher at equal values of $\dot{V}O_{2max}$, adding another reason that proves the advantage of using a wetsuit on swimming performance [22]. In addition, although different suits were used and at different velocities, C was reduced in open water swimming while using a full-body wetsuit for 5 km vs. swimming in the pool with a swimsuit [42]. This might suggest that using a full-body wetsuit might also affect the hydrodynamic position in long distances; thus, an increase in buoyancy should occur, reducing C.

Mixed findings of [$La^-$] were reported while using wetsuits vs. swimsuits in 400 m front crawl swimming (Table 3) [22,23,30]. Similar results were found for maximal HR [25,29,30], with higher values for 1500 m swimming [25] but lower for 400 m swimming in the swimming pool and flume compared to swimsuits [28,29]. These conflicting results might be a consequence of the body compression caused by the wetsuit [43]. Although lower [$La^-$] and HR values were expected while using wetsuits due to their reduced energy requirements, this fact remains unclear since the body temperature is affected both by the suit and the water temperature. This might trigger a higher physiological response at higher water temperatures, changing the results easily.

Comparing sleeveless long wetsuits vs. swimsuits, triathletes swam 10 and 7% faster at 17 and 18 °C (respectively) [1,25]. The explanation can rely on a lower maximal HR at 17 °C compared to warmer temperatures (21.3 and 29.5 °C). The same happened for core, trunk and rectal temperatures being lower at 17 °C while wearing a sleeveless long wetsuit compared to a swimsuit using skin thermistors [25]. These results suggest that this wetsuit increases trunk and rectal temperature as the water temperature increases, requiring maximal HR increments [25]. This explains why, in those cases, the immersion does not produce a cold-shock response, where lower HR is observed [44]. In addition, higher core temperature values were found when swimmers were wearing full-body wetsuits compared to swimsuits after 75 m swimming using a thermistor inserted through the anal sphincter and recorded every min [32]. It is also important to highlight that tight wetsuits increase the compression forces, consequently increasing the venous return and considered a risk factor for swimming performance [43]. For that reason, higher temperatures (>20 °C in open water swimming and ≥24.6 °C in triathlon events) probably should not be considered in studies with practical applications in training and/or competitive purposes.

Likewise, recent research stated that swimming 400 m with a full-body wetsuit at 18 °C allows better technique and economy of effort than when using a swimsuit. The use of a full-body wetsuit might increase performances at 18 °C water temperature, and its use is recommended in open water swimming competitions [28]. However, more studies are needed (i.e., regarding water temperatures where the use of a wetsuit is optional according to International Swimming Federation rules). In a short study where the full-body wetsuit Speedo Thinswim® was studied at 18 °C [45], the rating of perceived exertion showed lower values with this full-body wetsuit compared to a swimsuit. This can be related to the reduction in cardiorespiratory responses at similar velocities with the use of wetsuit vs. swimsuit [7,28–30]. In addition, it also shows useful information regarding the personal comfort of the swimmer while using the wetsuit and its usefulness for training purposes.

### *4.3. Wetsuit Use and Biomechanical Reports*

The reduction in drag force yield decreases in C, in addition to that higher swimming speeds can be sustained with elevated propelling efficiency and low hydrodynamic drag (i.e., low C) [46], as observed while using wetsuits. Indeed, lower passive drag and C were found in triathletes while swimming with a full-body wetsuit vs. swimsuit [9]. This can be explained by the increased buoyancy provided by the full-body wetsuit (higher body are covered compared to sleeveless long wetsuits). Another key aspect playing here is the higher frequency of full-body wetsuit use by less experienced swimmers vs. more experienced swimmers, resulting in the better performance of the latter with sleeveless long wetsuits in the 400 m front crawl [9,10]. The lower values found on active drag and in the drag–swimming velocity relationship with full-body wetsuits compared to swimsuits in short trials (23 m front crawl) also confirms the swimming efficiency improvements, probably due to the increased propelling efficiency [12]. However, the method used to analyze the active drag was different in the studies included in the present review; the velocity perturbation method was used in two cases, and thus it may influence the data [15,22]. In addition, in the measurement of active drag, it is important to consider that this system yields an increase in stroke efficiency (reduction in SR and an increase in SL). Moreover, this measurement is limited to the arm pull forces, and it requires mechanical adaptations because of the paddle placement [19,47].

Another predictor of C is the intracyclic velocity variation, as it describes the speed fluctuations resulting from changes in drag throughout the swimming cycles [13]. However, it was not used in any of the selected studies as a biomechanical measure. Considering that swimming speed variations produce drag modifications (i.e., form, friction and wave) and, consequently, energy expenditure changes [13], it would be interesting to compare intracyclic velocity variation with and without wetsuits. In addition, the taller the swimmer, the lower the wave drag, whereby the speed might increase and thus, leg sinking torque and C values can be reduced [13,48]. In addition, the full-body wetsuit use might reduce the local fatigue, which is associated with speed maintenance, resulting in lower C [19]. This is another advantage of the use of wetsuits which should be considered for open water swimming competitions.

Higher SR, SL and SI have been observed when wearing full-body wetsuits compared to swimsuits [9,16,22,23,27,30]. Swimmers who generally swim with higher SL would benefit more using a sleeveless long than full-body wetsuit, indicating that they are less adapted to wetsuits use than triathletes [10]. On the contrary, a better horizontal position evoked by the higher buoyancy provided while wearing a full-body wetsuit [20] reduces the hydrodynamic drag and leads to more efficient swimming [13]. This could be related to the wetsuit thickness. The wetsuits included in this review had a 3.15 mm average thickness (Table 2), which facilitates their adaptation, especially for more skilled swimmers (as discussed above).

Regarding swimming efficiency, no differences were found in propelling efficiency between full-body wetsuits and swimsuits both in the swimming pool and flume [16,28]. Nevertheless, some reports showed higher values in SL and SI using full-body wetsuits, which might be responsible for the higher velocity reached in 400 m swimming [16,28]. As one of the C determinants, propelling efficiency has been little studied despite having been used to determine the wetsuit type that fits the swimmer or triathlete better [13]. Complementarily, the index of coordination (another indicator of swimming efficiency quantified by the arm coordination [13,49]) has been studied, showing lower values in catch-up coordination mode when comparing full-body wetsuits vs. swimsuits in the 800 m front crawl [20], despite no changes being reported in 1500 m swimming nor in incremental trials [19,21]. These results suggested that some kind of adaptation to the wetsuit exists, but more data are necessary to conclude which one is the most useful for training purposes.

### 4.4. Wetsuit Use Effect in Swimmers and Triathletes

The first study that compared swimming performance between international swimmers and triathletes reported that the full-body wetsuit improves performance in triathletes compared to using a swimsuit [9]. In addition, this full-body wetsuit generates more benefits in triathletes than in swimmers [9]. In addition, $[La^{-}]$ and SR were higher, and C and passive drag were lower while using swimsuits in swimmers compared to triathletes [9]. Concerning these results, the lower hydrodynamic lift shown in triathletes compared to swimmers would justify the swimming technical abilities (i.e., poor horizontal position in triathletes), resulting in lower buoyancy and, therefore, higher hydrodynamic drag [12,13]. Moreover, the increased buoyancy caused by the neoprene synthetic rubber composition [6] could justify why the wetsuit seems to benefit triathletes more than swimmers (which already have better hydrodynamic position due to their higher technical ability).

A few years later, the previous data were confirmed by showing that regional-level swimmers improved swimming performance with the use of sleeveless long wetsuits compared to swimsuits [10]. It appears that when using a sleeveless long wetsuit, the more experienced swimmers will reach better performance compared to a full-body wetsuit, which may be explained by the discomfort and limitation of movements while wearing full-body wetsuits in the shoulder joint. A performance improvement was associated with the increase in swimming speed (7.1 and 11.3%) and SL (6.4 and 8.4%) when using a full-body wetsuit by regional-level swimmers and national-level triathletes, respectively. Nevertheless, using a sleeveless long wetsuit seems to increase swimming speed by 11.8% compared to swimsuits in swimmers [10]. In short, future research might consider further analysis comparing swimmers and triathletes due to their swimming technical differences and practical abilities which might determine different effects on swimming performance.

### 4.5. Current Study Limitations

Regarding the data extraction of the studies included, some limitations were observed. Three studies did not identify the wetsuit type nor the thickness, which is determinant to understanding the performance, physiological and/or biomechanical changes in swimming compared to swimsuits and therefore its application in swimming training and competition. Based on the quality assessment (Table S2), future studies should perform the following: (i) define the inclusion and exclusion criteria of the sample included and (ii) identify the confounding factors and detail the strategies to deal with them. Regarding these issues, the results reported should be focused on the sample and the swimming level to enhance the understanding and its application in swimming performance.

Related to the data collection environment, an important constraint is the lack of studies performed in colder water temperatures where the use of wetsuits is optional according to International Swimming Federation and International Triathlon Union rules (i.e., 18–20° and 16–22 °C, respectively) [3,4]. While it is consistently found that the wetsuit use improves swimming performance when the water temperature is about 25–29 °C, this seems not to be valuable practical information for training or competition purposes, because swimmers will be only allowed to use wetsuits when the water temperature is lower. Future studies about using wetsuits should focus primarily on simulating real competition temperatures and not only be conducted in indoor pools, where the normal water temperature is ~26 °C (an unreal scenario in open water swimming events). Finally, most of the studies were conducted on short- or long-course pools and in swimming flumes, which are not competition environments. Researchers should put more effort into measuring both physiological and biomechanical variables in open water scenarios.

## 5. Conclusions

According to the results observed in the current systematic review, the physiological and biomechanical changes produced by wetsuit use lead to an increase in swimming speed when wearing the full-body, sleeveless long and short wetsuits compared to swimsuits. This enhancement is mainly obtained due to higher buoyancy and hydrodynamic drag reduction. Plus, the technical adaptations seem to also contribute to swimming, with less energy requirements while using wetsuits. The findings of the current systematic review provide useful information for coaches, swimmers and triathletes about the use of full-body, sleeveless long and short wetsuits. The three suit types improve swimming performance compared to swimsuits in different swimming distances and aquatic environments. As a result, coaches, swimmers and triathletes could design their training routines with different wetsuits and strategies for open water swimming competitions.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/physiologia2040016/s1, Table S1: Search terms used in Web of Science, PubMed, Scopus and in the Conference Proceedings of the International Symposium on Biomechanics and Medicine in Swimming (BMS) databases. In addition, the sources where the additional records were found are detailed; Table S2: Quality assessment of the selected studies after researcher consensus; Table S3: Summary of the studies using different wetsuit types and swimmers or triathletes.

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