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Systematic Review

Effects of Resisted Methods upon Sprint Performance in Rugby Players: A Systematic Review

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Abstract: The resisted method can provide an effective way to improve sprinting in both the acceleration and maximal velocity phases. However, substantial discrepancies exist in the literature regarding the influence of the athletes' training status and the prescription of the load to be used in relation to the specific components of the desired sprint performance and its phases. The aim of this study was to carry out a systematic review of the research that analyzes the effects of the application of a sprint overload in rugby players, as well as to establish the results obtained in relation to the percentage of the load applied. For this purpose, the guidelines provided in the PRISMA Declaration were followed, and a search was conducted in five databases: PubMed, Web of Science, PsycInfo, Scopus, and SPORTDiscus. After screening, a total of 16 reports were included that met the proposed eligibility criteria. The results yielded information based on the effect of the application of an overload on the following aspects: (1) adaptation to training; (2) acute post-activation potentiation effect; and (3) acute effect and its influence on running kinematics and kinetics. It can be concluded that in order to work on weighted sprint training, the percentage of load to be used must be taken into account, as this percentage will determine to a large extent the effect that will be produced when it is applied.

Keywords: resistance training; resisted weighted training; resisted sprinting; acceleration; velocity; kinematics and kinetics

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1. Introduction

Rugby is an intermittent sport that is characterized by demanding high-intensity actions, interspersed with medium and low-intensity actions where player participation requires highly demanding actions such as tackles, scrums, rucks, and mauls with the aim of gaining possession of the ball [1]. Various studies have analyzed the distance that players travel in a rugby match, detecting certain differences depending on the position of the player, whether they are forwards or backs. Data show that the distances traveled are between approximately 4200 m and 6500 m. In general, backs run further and perform a higher number of accelerations than forwards during team training sessions and in matches [2,3]. Other studies focus on the analysis of movement intensity and the importance of the player's ability to accelerate and decelerate [4]. In this regard, it should be noted that in team sports such as rugby, the ability to accelerate is considered one of the determining aspects of a player's performance [5]. According to Cunningham et al. [6], the ability to accelerate, understood as the rate of change of velocity, is more important than peak velocity in determining success in team sports.

In addition to being a determining factor, sprinting ability is a differentiating factor between players, and it has been shown that players with greater sprinting ability are more likely to progress to higher divisions, both at junior and senior levels [7]. Along these lines, recent studies indicate that athletes participating at higher competitive levels perform a greater number of sprints than athletes competing at lower levels [8].

Sprints are very present in rugby matches, often preceding decisive actions in the game [9]. According to Austin et al. [2], elite rugby players, depending on their position, perform between 43 and 53 sprints on average per match, generally covering distances of less than 20 m and lasting less than 4 s. Very similar data are provided in studies with football players. Barnes et al. [10] analyzed, among other aspects, the number of sprints in a football match over a period of seven seasons in the English Premier League. The data showed an increasing proportion of actions of an explosive nature throughout the seasons studied, from 31 ± 14 sprints per match (season 2006–07) to 57 ± 20 (season 2012–13). On the other hand, Fílter et al. [11] examined the behavior of football players as a function of the trajectory of the sprint (linear sprint 17 m/sprint in curve 17 m). They observed that a large number of the subjects (27 out of 45 subjects) showed higher performance in one direction of the race in the curve sprint than in the linear sprint, alluding that this could be due to the specificity of the test, since the curve sprint is usually more frequent than the linear sprint in football.

It is clear, and this is demonstrated by a multitude of research, that improving the performance of velocity actions must pay special attention to the development of the ability to accelerate. Numerous methods have been investigated so far, as well as their combination, including unloaded sprint work, top and explosive strength training, and plyometrics, and, as of today, no training method has re-emerged as a priority or as superior to others [12].

In relation to sprinting, Alcaraz et al. [13] distinguish two phases: on the one hand, the acceleration phase, and on the other hand, the maximal velocity phase. The acceleration starts from a practically static position and increases its velocity as the subject moves, while during the maximal velocity phase, the subject moves and increases its velocity of displacement. It is important to understand that the phases have different characteristics, which is why they must be trained both together and separately. In the case of acceleration, it is necessary to identify which muscle groups are involved in it, such as the ankle, knee, and hip extensors [14]. It is known that the time between the initial position and the first application of force is limited, which is called the development of maximal force in the shortest possible time or rate of force development (RFD). For an optimal application of the force, it is crucial that the position of the subject is correct. Thus, the subject should position himself with a slight inclination of the body, as it is necessary for the development of the ground reaction force (GRF), which is used to bring the body forward with the participation of the contact time (CT) and its relationship with the horizontal-vertical force [15,16]. Maximal velocity is limited by peak GRF (horizontal force), leading to a strong relationship between GRF and maximal velocity (MV) during the main part of the stance phase [17]. During the maximal velocity phase, a production of asymmetric force is created, and RFD is very high, resulting in much shorter contact times than in the acceleration phase [13].

Kirkpatrick and Comfort [18] highlight the importance of lower limb strength in improving sprint performance, which is crucial for improving acceleration over short distances and is a key feature of the game. Thus, improving sprint performance and its components is considered very important within strength and conditioning training programs in team sports [19]. In this sense, weighted sprint training allows athletes to run with an additional overload, i.e., with resistance using a weight waistcoat, parachute, or sledge.

The different modalities of weighted sprint training are conducted horizontally and involve those muscles, velocities, and ranges of movement belonging to the sprint phases [20].

Previous studies have shown that with weighted sprint training, there is an increase in torso inclination, a greater demand for horizontal forces caused by the load to be moved, an increase in ground contact time during running, a considerable knee flexion angle, a greater propulsive thrust and braking forces, as well as a decrease in average vertical force, maximal hip flexion, and stride frequency [21,22]. In addition, Bachero-Mena et al. [23] claim that this type of training method results in improvements in sprint performance due to increased horizontal force production during ground contact time, increased stride length in the acceleration phase, and improved maximal velocity.

In terms of physical performance, back players generally cover greater distances at higher speeds than forward players [24]. Therefore, the sprint performance and acceleration phase are variables of great interest to the strength and conditioning professional working with rugby players, as they are fundamental aspects that apply during the game [25]. For a rugby athlete to be successful, it is believed that they must be proficient in all phases of sprinting, including the initial acceleration and maximal velocity phases to compete at the elite level [26].

Other effects produced by weighted training are of an acute nature, which refers to post-activation potentiation (PAP), affecting the benefits of jumping, throwing, upper-body ballistic movements, and sprinting [27]. Several studies have shown that a light sledge load is not suitable for improving acute sprint performance, as it does not produce any significant improvement by using loads below 30% of body mass [28,29]. Recently, new studies determined that a load of 75% of body mass produces improvements in acute sprinting over distances of 15 and 20 m, leading to an improvement in the PAP [29–31].

Bearing in mind the above, by providing resistance at the moment of sprinting, athletes' running is affected, and the greater the resistance load, the slower athletes will run, so they will have longer times to apply a greater amount of force during their displacement [23,32]. Therefore, if high loads are used, overloads will occur in the muscle groups involved in sprinting, and sprinting mechanics and performance will be affected [33]. Training professionals should be aware that when applying an overload to the sprint, there are modifications in the acceleration and maximum speed phases where the mechanisms of the race are modified, so they should be clear about which sprint phase they want to work, since at a higher load, the acceleration phase will improve, but if the load is lower, the phase benefited will be the maximum speed [32,33]. Therefore, the aim of this study was to carry out a systematic review of the research that analyzes the effects of the application of a sprint overload in rugby players, as well as to establish the results obtained in relation to the percentage of the load applied. In this regard, it is hypothesized that the resisted method produces improvements in sprint performance, as well as benefits for PAP.

2. Materials and Methods

To carry out this systematic review, we followed the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) [34] and the practical guide for systematic reviews [35,36]. At the beginning of the systematic review, the procedures to be carried out were established. The present review was incorporated into the International Prospective Register of Systematic Reviews (PROSPERO), being identified with the reference number CRD420251009003.

2.1. Eligibility Criteria

The eligibility criteria used (inclusion and exclusion) following the PICO search strategy are set out below (Table 1).

Table 1. Eligibility criteria.

PICO	Inclusion Criteria	Exclusion Criteria
P (Population)	Participants were healthy subjects, male or female rugby players over 18 years of age	Studies that include participants in other sports over 18 years of age
I (Intervention)	Quantitative studies in which the intervention had to have a pre-test and post-test and no time limit on the intervention and performed with resistance or weight	Studies that do not include an intervention with resistance or weight
C (Comparison)	Control group (unresisted sprint training) vs. experimental group (resisted sprint training) OR multiple experimental groups with different training methodologies	Not meeting this criterion
O (Outcomes)	Studies should state the load used and the distance studied. The effect of the study should be acute or proposed training methodology	Studies that do not report these results
Other criteria	Full and original experimental studies text articles Studies written in English and Spanish	Systematic or literature reviews Manuscripts conceived as opinion articles, theses, conference proceedings, books or book chapters Articles without full text availability Manuscripts not written in English or Spanish

2.2. Source of Information and Search Strategies

The systematic search was carried out between December 2024 and February 2025 using the following databases: PubMed, Web of Science, PsycInfo, Scopus, and SPORTDiscus. There were two reasons for selecting these databases: (1) research articles published in journals with a Journal Citation Reports (JCR) impact factor and indexed in the Scientific Journal Rankings (SJR) are included and (2) these are reference databases for research publications, in the fields of both education and sports.

When searching the databases, Boolean operators AND and OR were used to connect and separate the different terms included in the search phrase. The search phrase was structured in three blocks: *(1) Resisted sprint training OR Resisted velocity-based training *(2) AND Rugby OR Football *(3) AND Intervention OR Experimental OR Quasi-experimental OR Randomized controlled trial.

2.3. Selection of Studies and Data Extraction Process

After searching for the different studies in each database, with the filters applied, a result of 363 studies was obtained. After the analysis of titles and abstracts and after discarding those studies that did not meet the eligibility criteria established in this research, a total of 16 publications were selected for study in this systematic review. To reduce selection bias, data extraction was performed by two investigators individually. These researchers are specialists and experts in the selection of studies and in the process of extracting data from selected studies in systematic reviews, as they have great experience in this regard. However, in case of discrepancies, these were resolved in consultation with the third investigator.

2.4. Quality Assessment

Once the articles had been selected for analysis, their quality was assessed using the evaluation tool "Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields" [37]. Each study was evaluated using an instrument composed of 14 specific items for quantitative research, aimed at evaluating key aspects such as study design, sample characteristics, methodology used, data analysis, and presentation of results and conclusions. The score of these items was assigned based on the level of compliance observed in each research: 2 (satisfactory), 1 (partially satisfactory), 0 (unsatisfactory), and NA (not applicable). The final score was obtained by the following formula [("satisfactory numbers" × 2) + ("partially satisfactory numbers" × 1)/28 − ("not applicable numbers" × 2)]. The scores obtained were expressed as percentages, ranging from 0 to 100%.

The risk of bias in the studies was assessed using the "Tool for Quality Assessment and Notification of Exercise Studies (TESTEX) scale" [38]. This tool includes 12 evaluation criteria and allows a maximum score of 15 points per study to be assigned. A higher score indicates a lower probability of bias. According to baseline values, the risk of bias is classified as high (≤4 points), medium (between 4 and 11 points), or low (≥11 points).

Two investigators (L.M.E. and M.T.A.R.) with great experience and knowledge related to the application of quality assessment tools, evaluated the quality of studies individually and independently, seeking the greatest possible objectivity. In the case of discrepancies, they were resolved by the third experienced investigator (F.J.G.F.-G.).

3. Results

3.1. Selection of Studies

Figure 1 shows a flow chart summarizing the main results of the search carried out. After searching for individual studies in each database, with filters applied, there was an initial result of 362 papers: (1) PubMed (n = 62); (2) Web of Science (n = 14); (3) PsycINFO (n = 1); (4) Scopus (n = 1); and (5) SPORTDiscus full text (n = 284) were obtained for examination (see Figure 2). These reports were then screened and analyzed on the basis of the titles and abstracts in order to select the researches according to the subject matter. After this first screening, a total of 347 documents were excluded for the following reasons: (1) they were duplicates (n = 20); (2) they were literature reviews, systematic reviews, or meta-analyses (n = 30); (3) they did not correspond to the topic (n = 286); (4) they were not scientific articles (n = 6); (5) they were not in full text (n = 1); or (6) they were not given pre and post (n = 4). On the other hand, one more study was identified through another method (after examining the references of the included articles). Once the title and abstract had been analyzed and screened, it was included in the study. Finally, a total of 16 publications were included in the review.

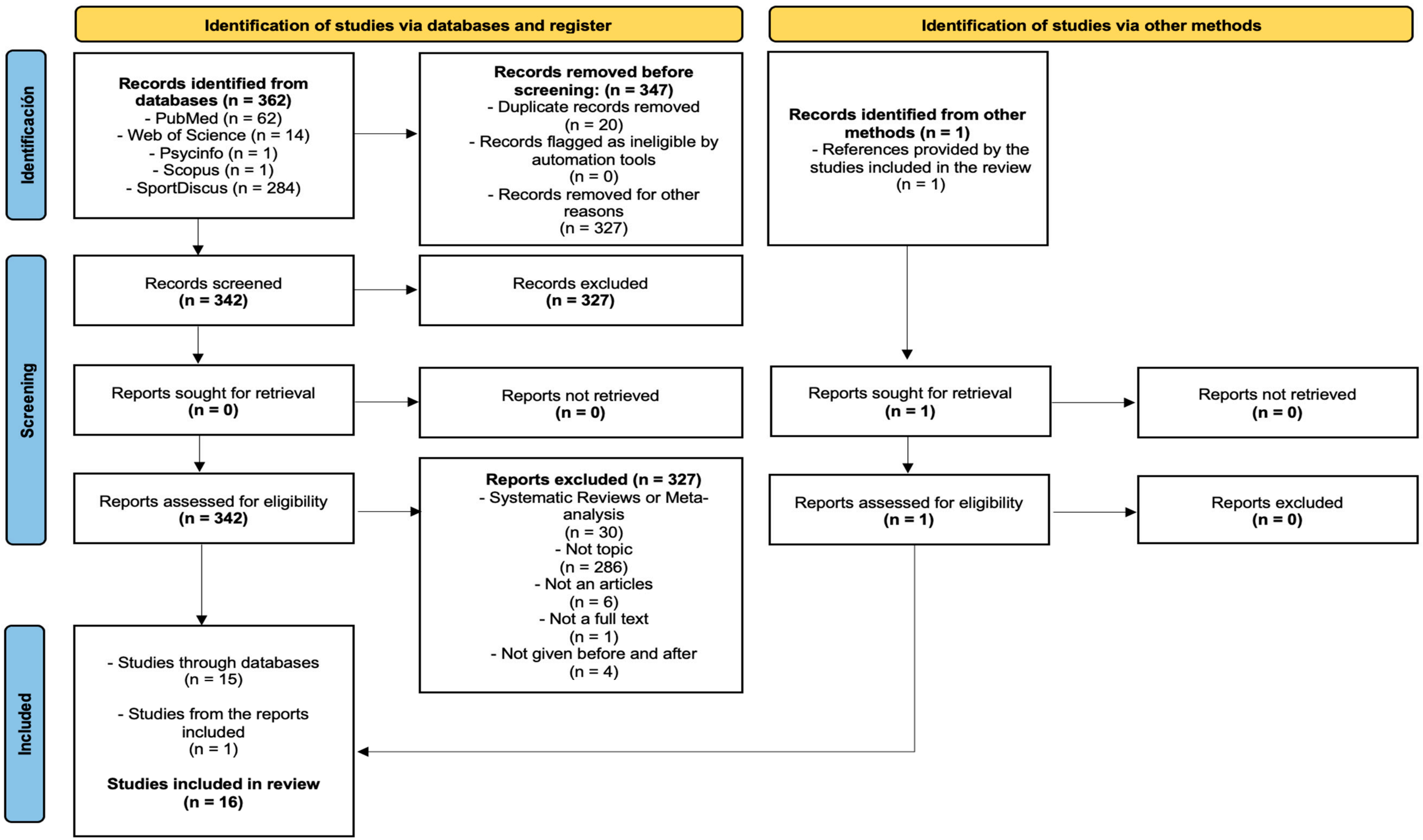

Figure 1. Flowchart of the systematic review process according to the PRISMA protocol declarations.

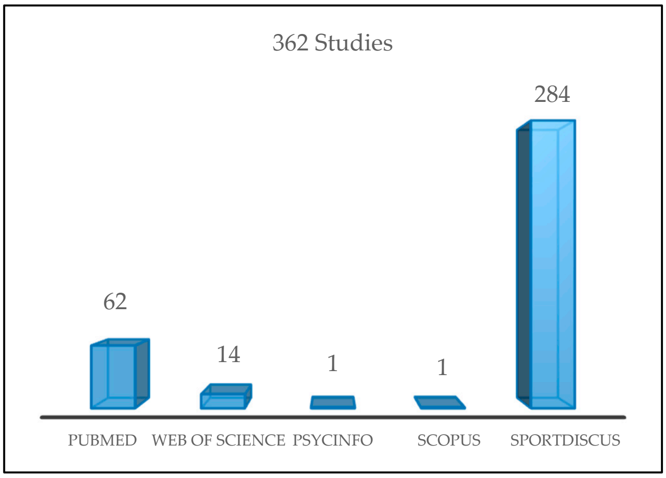

Figure 2. Search results in databases.

3.2. Quality of Studies

The quality scores of the articles were expressed as percentages, ranging from 0 to 100%, ranging from 0.67 to 0.92 (see Table 2).

Inter-rater agreement was calculated using the intra-class correlation coefficient, resulting in a score of (CCI) 0.939 (p < 0.001), which is considered excellent [39]. After implementing the inter-rater agreement, a conservative cut-off point was agreed upon for the selection of evaluators, including studies with scores of no less than 67% (>0.67).

Table 2. Quality assessment of quantitative studies.

Studies	Observer 1	Observer 2
Spinks et al. (2007) [40]	0.82	0.82
Harrison and Bourke (2009) [41]	0.78	0.78
Lockie et al. (2012) [42]	0.82	0.82
West et al. (2013) [43]	0.71	0.67
Bentley et al. (2016) [20]	0.78	0.82
Winwood et al. (2016) [31]	0.85	0.85
Seitz et al. (2017) [30]	0.78	0.71
Macadam et al. (2017) [44]	0.78	0.78
Cross et al. (2018) [45]	0.82	0.82
Lahti et al. (2020) [46]	0.85	0.85
Cochrane et al. (2021) [47]	0.78	0.82
Martínez-Serrano et al. (2021) [48]	0.75	0.71
Sinclair et al. (2021) [49]	0.92	0.92
Escobar et al. (2021) [50]	0.89	0.89
Zabaloy et al. (2022) [19]	0.82	0.85
Pareja-Blanco et al. (2022) [33]	0.78	0.79

The methodological quality of the included studies is detailed in Table 3. The average score obtained was 8 ± 2.3 points, with a range between 5 and 12. Three studies were classified as having low risk of bias [42,45,50], while thirteen presented a moderate risk [19,20,30,31,33,40,41,43,44,46–49], and none were identified as high risk.

Table 3. Score of the methodological quality of the studies considered in the review.

	Items												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
Spinks et al. (2007) [40]	1	1	1	0	0	2	0	2	1	0	1	1	10
Harrison and Bourke (2009) [41]	1	1	1	0	0	2	0	2	1	0	1	1	10
Lockie et al. (2012) [42]	1	1	1	1	0	2	0	2	1	0	1	1	11
West et al. (2013) [43]	1	1	1	1	0	1	0	1	1	0	1	1	9
Bentley et al. (2016) [20]	0	0	0	0	0	2	0	0	1	1	1	1	6
Winwood et al. (2016) [31]	1	0	0	0	0	2	0	0	1	1	1	1	7
Seitz et al. (2017) [30]	0	0	0	0	0	2	0	0	1	0	1	1	5
Macadam et al. (2017) [44]	1	0	0	0	0	2	0	0	1	0	1	1	6
Cross et al. (2018) [45]	1	1	1	1	0	2	0	2	1	1	1	1	12
Lahti et al. (2020) [46]	1	0	0	1	0	2	0	2	1	0	1	1	9
Cochrane et al. (2021) [47]	0	0	0	0	0	2	0	0	1	0	1	1	5
Martínez-Serrano et al. (2021) [48]	1	0	0	0	0	2	0	0	1	1	1	1	7
Sinclair et al. (2021) [49]	0	1	1	1	0	2	0	1	1	0	1	1	9
Escobar et al. (2021) [50]	0	1	1	1	0	2	0	2	1	1	1	1	11
Zabaloy et al. (2022) [19]	1	0	0	0	0	2	0	0	1	0	1	1	6
Pareja-Blanco et al. (2022) [33]	0	0	0	0	0	2	0	0	1	0	1	1	5

Explanation of the items: 1: eligibility criteria specified (1 point); 2: randomization defined (1 point); 3: allocation concealment (1 point); 4: groups similar at baseline (1 point); 5: assessor blinding in study reporting (1 point); 6: outcome measures assessed in 85% of patients (3 points); 7: intention-to treat analysis (1 point); 8: between-group statistical comparisons reported (2 points); 9: point measures and measures of variability for all reported outcome measures (1 point); 10: activity monitoring in the controlled group (1 point); 11: relative exercise intensity remained constant (1 point); 12: exercise volume and energy expenditure (1 point).

3.3. Characteristics of the Studies

Table 4 lists all the studies that were included in the review in relation to the country in which the research was carried out, number of subjects participating, age of participants, height and weight of participants, the sports played by the participants, and the level of competition they were in at the time. Lastly, the effect of the intervention is shown, either as an adaptation to training or as an acute effect caused by the intervention.

Table 5 shows the distance studied, study groups, volume of time, load applied, aim, methodology, and main results of the investigations.

Table 6 shows parameters related to the acute effect (distance studied, study groups, volume of time, load, recovery time, and effects of the research). Table 7 includes aspects related to post-activation potentiation (weight, surface, objectives, and outcome of the research), while Table 8 shows the kinematics and kinetics of the race weight, area, objectives, and main results of the research.

Table 4. Study, country, subjects, age, height, weight, sport, level, and effect of research.

Study	Country	Subjects	Age (M ± SD)	Height CM (M ± SD)	Weight KG (M ± SD)	Sport	Level	Effect
Spinks et al. (2007) [40]	Australia	30 men	21.8 ± 4.2	181.9 ± 6.2	83.3 ± 8.7	Rugby, Football, and Australian Football	Professionals	Adaptation to training
Harrison and Bourke (2009) [41]	Ireland	50 men	20.5 ± 2.8		87 ± 10.5	Rugby	Professional and Semi-professional	Adaptation to training
Lockie et al. (2012) [42]	Australia	35 men	23.1 ± 4.2	182 ± 0.1	83.1 ± 8.6	Australian Football	Semi-professionals	Adaptation to training
West et al. (2013) [43]	United Kingdom	20 men	SLED = 26.8 ± 3.0; TRAD = 25.1 ± 3.2	SLED = 186 ± 8 cm; TRAD = 185 ± 7	SLED = 90.2 ± 10.3; TRAD = 90.9 ± 10.6	Rugby	Professionals	Adaptation to training
Bentley et al. (2016) [20]	United Kingdom	12 men	18.06 ± 0.6	180 ± 0.06	90.2 ± 10	Rugby	Elite	Acute
Winwood et al. (2016) [31]	New Zealand	22 men	22.4 ± 3.0	178.3 ± 6.2	87.6 ± 13.0	Rugby	Semi-professional	Acute
Seitz. et al. (2017) [30]	Australia	20 men	18.4 ± 0.8	180 ± 8	80.4 ± 6.8	Rugby	Professionals	Acute
Macadam et al. (2017) [44]	New Zealand	19 men	19.7 ± 2.3	181 ± 6.5	96.1 ± 16.5	Rugby	Amateurs and Semi-professionals	Acute
Cross et al. (2018) [45]	Finland and France	36 women and men	Football: 27.1 ± 4.8 Rugby: 27.1 ± 2.3	Football: 176 ± 3.6 Rugby: 175 ± 9.7		Football and Rugby	Professionals	Adaptation to training
Lahti et al. (2020) [46]	France	16 men	Resisted: 19 ± 0.3; Assisted: 20 ± 1	Resisted: 183 ± 0.1; Assisted: 190 ± 0.1	Resisted: 91.4 ± 15.3; Assisted 94.4 ± 9.1	Rugby	Professionals	Adaptation to training
Cochrane et al. (2021) [47]	New Zealand	12 men	20.4 ± 1.2	183 ± 7.3	95.2 ± 10.2	Rugby	Senior	Acute
Martínez-Serrano et al. (2021) [48]	Spain	9 men	21.3 ± 4.3	176.6 ± 8.8	75.8 ± 10.2	Rugby	Amateur	Acute
Sinclair et al. (2021) [49]	United Kingdom	28 men	18.8 ± 0.6	182.2 ± 5.5	87.6 ± 11.4	Rugby	Elite	Adaptation to training
Escobar et al. (2021) [50]	Spain	31 women	23.7 ± 3	167.5 ± 5.2	69 ± 9	Rugby	Amateur	Adaptation to training
Zabaloy et al. (2022) [19]	Spain	12 men	23.5 ± 5.1	179 ± 0.04	82.5 ± 13.1	Rugby	Amateur	Acute
Pareja-Blanco et al. (2022) [33]	Spain	18 Men	Sprinters 23.3± 5.6 Rugby players 21.3 ± 3.3	Sprinters 178.06 ± 5.6 Rugby players 179 ± 0.05	Sprinters 75.2 ± 7.6 Rugby players 89.7 ± 18.8	Rugby and Sprinters	Professionals	Acute

M: mean; SD: standard deviation; SLED: experimental training; TRAD: traditional training.

Table 5. Training adaptation: Distance studied, study groups, volume of time, load applied, aim, methodology, and main results of the investigations.

Studies	Distance Studied	Study Groups	Volume of Time	Load Applied	Aim	Methodology	Main Results
Spinks et al. (2007) [40]	A- 0 to 5 m B- 5 to 10 m C- 10 to 15 m D- 0 to 15 m	1- RS 2- RST 3- CG	8 weeks with two sessions	The external resistance to the RS group was established in two parts: firstly, the required load based on body mass percentage, and secondly, based on velocity	To determine the long-term effects of RS sprint training in the form of a weighted sledge tow on acceleration performance, leg power, and acceleration kinematics	8 weeks, two non-consecutive 1 h sessions on wooden surface	Significant sprint improvement in all intervals but no major differences between RS and NRS training
Harrison and Bourke (2009) [41]	A- 0 A 5 m B- 0 to 10 m C- 0 to 30 m	1- CG 2- EG	6 weeks with two sessions	The default loads for the sledge were 12.6–13% of body mass	To determine the effects of a 6-week RS training intervention on 30 m sprint times and the maximal velocity achieved in 30 m sprints from a static take-off and 30 m sprints in flight	6 weeks, two sessions per week on an indoor track	Significant improvement in acceleration (first 5 m), no significant changes in 30 m sprint times
Lockie et al. (2012) [42]	A- 0 to 5 m B- 5 to 10 m C- 0 to 10 m	1- FST (n = 9) 2- WT (n = 8) 3- PT (n = 9) 4- RST (n = 9)	6 weeks with two sessions	The group towed a load equivalent to 12.6% of body mass	To provide specific data on the adaptations resulting from free sprinting (FST), weight training (WT), plyometric exercises (PT), and resisted training (RST) with the specific aim of improving 10 m sprint velocity	6-week training program, two weekly 1 h sessions	All training groups improved 0–5 m sprints; plyometric and resisted sprint showed greatest start-up benefits
West et al. (2013) [43]	A- 0 to 10 m B- 0 to 30 m	1- SLED 2- TRAD	6 weeks with two sessions	A load of 12.6% of body mass was used	To compare the effects of a combined program of velocity training and sledge tow with weights versus traditional velocity training in a group of professional rugby players only	6-week program, two sessions/week on a rubber track	Both approaches improved acceleration (10 m and 30 m); sledge training yielded greater velocity gains
Cross et al. (2018) [45]	A- 0 to 15 m B- 0 to 20 m C- 0 to 30 m	1- FLPT 2- L10	6 weeks with two sessions	Five sprint conditions were prescribed for each athlete: no resistance, 25, 50, 75, and 100% of body mass	To compare the effects on sprint performance and mechanical outcomes of a resistance sprint training program focused on the individual optimal load for maximal power versus the control group that had a lighter load associated with a 10% decrease in maximal running velocity	12 sessions, load tailored to decrease max velocity by 10%	Both training conditions improved performance metrics

Table 5. *Cont.*

Studies	Distance Studied	Study Groups	Volume of Time	Load Applied	Aim	Methodology	Main Results
Lahti et al. (2020) [46]	A- 0 to 10 m Assisted B- 0 to 20 m Resisted	1- Assisted 2- Resisted	8 weeks with two sessions	The load for the sledge was 70–80% of VO, in the case of the assisted training, a percentage of 105–110% of maximal velocity was used	To quantify the influence of initial sprint force-velocity properties on changes in individual sprint force-velocity profiles by training at different ends of the sprint force-velocity spectrum and to demonstrate individual peak responses. Specifically, changes were targeted using horizontally oriented training modalities; resisted and assisted training, standardized by velocity	8-week intervention, 12 sessions on indoor artificial turf	Sprint strength-velocity profile helps predict training adaptation; resisted training improved 20 m sprint significantly
Sinclair et al. (2021) [49]	A- 0 to 5 m B- 0 to 10 m C- 0 to 20 m	1- CG 2- EG	8 weeks with two sessions	The sledge loads were determined to produce the required 20% reduction in velocity over 10 m	To examine through a randomized trial the efficiency of resisted sledge training compared to traditional unresisted sprint training in terms of mediating improvements in velocity, agility and power over an eight-week training period during the season in elite rugby players	8-week intervention, twice weekly in scheduled gym sessions	5 m sprint improved at 4 weeks, 10 m at 8 weeks, no major differences between groups
Escobar et al. (2021) [50]	A- 0 to 5 m B- 0 to 10 m C- 0 to 15 m D- 0 to 20 m E- 0 to 25 m F- 0 to 30 m	1- CG 2- FG 3- BG	8 weeks with two sessions	The control group (CG) followed unresisted sprint training (URS), while the FG and BG ran towing a resisted sledge attached to their waist, with an optimal load for FG = 89.1 ± 6.4% and BG = 80.5 ± 6.7% of their body mass	To observe the effect of 8 weeks of optimally loaded sledge training for maximal power output in 5 m and 20 m sprint performance and to determine whether the initial level of strength determines the magnitude of improvement in individual mechanical sprint outputs in the horizontal power-force. Strength-velocity profile and sprint performance in amateur female rugby players	8-week program, two weekly sessions (16 total)	Horizontal force level influences adaptation; training at 80% BM enhances max velocity and strength relationship

m: meters; RS: unresisted sprint; CG: control group; RST: resisted sprint; EG: experimental group; FST: free sprint; WT: weights; PT: plyometric exercises; SLED: experimental training; TRAD: traditional training; FG and BG: experimental groups; NRS: no sprint resistance; BM: body mass; F0: initial force; L10: individual maximal velocity decrease.

Table 6. Acute effect: Distance studied, study groups, time volume, load, recovery time, and research effects.

Studies	Distance Studied	Study Groups	Volume of Time	Load	Recovery Time	Effects
Bentley et al. (2016) [20]	A- 0 to 6 m	EG	One week	10, 15, and 20% VDEC	3 min	Kinematics and kinetics of running
Winwood et al. (2016) [31]	A- 0 to 5 m B- 0 to 10 m C- 0 to 15 m	EG	21 days (three sessions)	75 and 150% of BM	4, 8, and 12 min	PAP
Seitz et al. (2017) [30]	A- 0 to 5 m B- 0 to 10 m C- 0 to 20 m D- 10 to 20 m	EG	Two weeks	74 and 125% of BM	15 s, 4, 8, and 12 min	PAP
Macadam et al. (2017) [44]	A- 0 to 2 m B- 0 to 5 m C- 0 to 10 m D- 0 to 20 m E- 10 to 20 m	1- AWR 2- PWR	One session	AWR and PWR 3% of BM	4 min	Running kinematics
Cochrane et al., (2021) [47]	A- 0 to 5 m B- 0 to 10 m C- 0 to 15 m D- 0 to 20 m	EG	Three sessions	75 and 115% of BM	2, 4, 6, 8, 12, and 16 min	PAP
Martínez-Serrano et al. (2021) [48]	A- 0 to 15 m	EG	Two weeks	Sledge 20, 55, and 90% of BM. Parachutes xs, xl, and 3xl	3 min	Kinematics and kinetics of running
Zabaloy et al., (2022) [19]	A- 0 to 5 m B- 0 to 10 m C- 0 to 15 m D- 0 to 20 m E- 0 to 25 m F- 0 to 30 m	EG	One week (two sessions)	Velocity decrease 10, 30, and 50%	4 min recovery time	Kinematics and kinetics of running
Pareja-Blanco et al. (2022) [33]	A- 0 to 20 m	EG	One week (one session)	20 and 60% of BM	5 min	Running kinematics

AWR: anterior load; EG: experimental group; PWR: posterior load; BM: body mass; VDEC: velocity decrease; PAP: post-activation potentiation.

Table 7. Post-activation potentiation: Weight, surface, aims, and results of the investigations.

Studies	Weight	Surface	Aims/Hypotheses	Results
Winwood et al. (2016) [31]	11.5 kg sledge	Indoor artificial turf	It was hypothesized that the heavy sledge pull condition at 150% of body mass with an 8 min rest period would induce a greater potentiating effect (faster) on sprint times than the lighter sledge condition at 75% body mass	The main findings of this study were that the 75% sledge load demonstrated small improvements in 5, 10, and 15 m group sprint times after 8 and 12 min of recovery, with significantly faster recovery. The slowest group sprint times were associated with the 150% sledge pull for the 5 and 10 m group sprint times after 4 min of recovery
Seitz. et al. (2017) [30]	Sledge	Indoor artificial turf	Investigate the effects of performing a single sledge push loaded with 75 or 125% of body mass on subsequent sprint exercise	The findings showed a potentiating effect for 75% limited to 15 s, but beneficial at 4 min pause and with a very beneficial effect at 8 and 12 min rest. In contrast, with the 125% load, it was slower throughout 8 and 12 min, with the possibility of being considered harmful at 15 s and 4 min.
Cochrane et al. (2021) [47]	Sledge 12.5 kg	Wooden surface covered by a 4 mm carpet	To determine whether individualizing sledge loads with a 35 and 55% reduction in velocity would improve performance in the 20 m sprint	It was found that reducing the maximal velocity by 35% with a single pull of the resistance sledge improved the velocity at 20 m compared to the heavier sledge load, but there was no significant change in velocity at 5, 10, and 15 m

Table 8. Kinematics and kinetics of running weight, surface, aims, and main research results.

Studies	Weight	Surface	Aims/Hypotheses	Main Results
Bentley et al. (2016) [20]	Sledge	22 m laboratory	To investigate the kinetics and kinematics of uninhibited sprinting during the early acceleration phase of sprinting in an elite academy rugby league population	The main findings of this study were (a) as sledge loads increased, torso and lower limb kinematics altered to a greater extent; (b) there were no significant differences in maximal propulsive force between any of the sledge and uninhibited sprint conditions; and (c) momentum measures on the 20% Vdec sledge tests were significantly greater than all other conditions

Table 8. *Cont.*

Studies	Weight	Surface	Aims/Hypotheses	Main Results
Macadam et al. (2017) [44]	Compression trousers and sleeves	Indoor track	To determine the acute changes in kinematics and kinetics when WR equivalent to 3% of body mass was attached to the anterior or posterior surface of the lower limbs with distance of 20 m maximal velocity run. It was hypothesised that the 3% BM loads would have no effect on the variables of interest and that the comparative effects of anterior and posterior loads would not be significant	No statistical differences were found between AWR and PWR on any variable of interest. Therefore, the following discussion will focus on the WR conditions (AWR and PWR) compared to the sprint race with no loads. There were no significant differences in sprint split times from the start to the 2 m, 5 m, 10 m, and 20 m marks between the WR sprint race compared to the no-load condition. Finally, no difference in running kinematics was found between placing the WR on the anterior or posterior part of the thigh
Martínez-Serrano et al. (2021) [48]	Sledge and Parachute	Treadmill	To analyze muscle activation and kinematics of the resisted sledge and parachute push sprint with three loading conditions on the instrumented treadmill. The secondary goal was to examine the effect of load variation on power output in these specific exercises	The main findings of the study were as follows: (1) muscle activation of the vastus lateralis and gluteus medius (but not biceps femoris) increased according to load when pushing the sledge but not when using different sized parachutes; (2) increasing load in sled-push caused several changes in running kinematics, while only an increase in hangle was detected between sizes XL–3XL in parachute running; and (3) the loading conditions that produced the greatest power output in sledge-push and parachute were 55% BM and parachute size 3XL, respectively
Zabaloy et al. (2022) [19]	Sledge		To analyze and compare the effects of resistance training with sledge and without resistance using different loading conditions (i.e., 0, 10, 30 and 50% Vloss) on muscle activity, leg stiffness, and kinematics during 30 m sprints in amateur rugby players	As the sledge load increased, kleg (leg stiffness) decreased during the acceleration phase; however, in the Vmax phase, only the 50% Vloss condition resulted in significant reductions in Kleg compared to the remaining conditions (0, 10, and 30% Vloss)

Table 8. *Cont.*

Studies	Weight	Surface	Aims/Hypotheses	Main Results
Pareja-Blanco et al. (2022) [33]	Sledge	Sprinters, rubber surface, Rugbiers synthetic surface	Comparing changes in resisted sprint performance and kinematics caused by different sledge loads in sprinters and rugby players	Sprinters were faster than rugby players under light, unresisted loading conditions (i.e., 20% BM); however, these differences were not observed with heavier sledge loads (i.e., 60% BM). In addition, sprinters experienced lower Vdec than rugby players at 20% of BM, while rugby players showed less impairment in sprint velocity at 60 % of body mass. Running technique was altered differently by different loads in sprinters and rugby players during counter sprints, although no differences in SL were observed between the groups

WR: sprint with resistance; UL: unresisted sprint AWR: anterior resistance; PWR: posterior resistance; BM: body mass; Vloss: velocity decrease; Vdec: deceleration velocity; Kleg: leg stiffness; Vmax: maximal velocity.

4. Discussion

The aim of this study was to carry out a systematic review of the research that analyzes the effects of the application of a sprint overload in rugby players, as well as to establish the results obtained in relation to the percentage of the load applied. In this sense, it can be established that resisted training improves sprint performance, mainly in the acceleration phase. Moreover, the effect produced by the load is presented individually according to the characteristics of the subject.

4.1. Effect of Short-Term Training Taking into Account Load

In numerous studies on sprint training with resisted sledge to improve sprint performance, it is noted that there is no agreement on the quantification of the ideal sledge loads for each sprint performance improvement [13,51].

Despite the fact that in the specialized literature it is recommended to use relatively light loads (>10%), research related to the effect of toboggan towing where light loads are compared to heavy loads for the improvement in the performance of the sprint capacity questions this assertion. In this sense, Kawamori et al. [21] carried out a longitudinal randomized experimental design of two groups to compare the effects of sled towing training between heavy (heavy group; $n = 10$) and light (light group; $n = 11$), in which they showed that the training intervention in both cases was equally effective in improving the performance of the 10 m sprints, while the training with heavy loads improved the performance in 5 m sprints. Thus, Spinks et al. [40] corroborate that the sprint resistance training with a load of 5% of BM 4 kg (sled weight) improves the performance in acceleration but is no more effective than a sprint training program without load.

Overall, studies show that resisted training between 6 and 8 weeks of planning produces improvements in sprint performance, applying loads between 10 and 13% of body mass or with loads that do not reduce the athlete's velocity by more than 10% of unloaded sprint performance [13,40]. The findings support the use of a training load of approximately 13% of body mass for a run distance of 15 to 20 m [41] and 10 and 30 m runs with a load of 12.6% of BM [44], a significant improvement over traditional sprint training. These results are consistent with the indications set forth in other research related to the effects of sprint training with sled drag [22,52].

Recently, Rodríguez-Rosell [53], in their study on the effects of different loading conditions during resisted sprint training, found that after 8 weeks of training, the improvement in unloaded sprint performance improved in groups of athletes who had worked with loads of 40% of BM, while groups training with loads of 20 and 80% of BM did not show any significant improvements in sprint performance.

These findings are similar to those found by Alcaraz et al. [13]. It was also found that the use of 80% loads produced an improvement in horizontal strength over distances ranging from 0 to 20 m, even though it resulted in a loss of running technique due to the load applied. On the other hand, Spinks et al. [40] and Sinclair et al. [49] found that both resisted training and unloaded sprint training improved sprint performance.

On the other hand, studies corroborate that resisted sprint training is not an effective method for improving sprinting in the maximal velocity phase [51,53]. According to Alcaraz et al. [13], this may be due to the friction between the sledge and the surface of the tracks on which the race takes place.

4.2. Acute Post-Activation Potentiation Effect (PAP)

Within the differentiation of studies that investigated the acute effects produced by the application of an overload on sprint performance, there is the PAP effect. The find-ings show that a load at 75% of body mass or loads ranging from 30 to 35% of the reduc-tion in velocity produce a beneficial effect on post-activation sprint performance over dis-tances ranging from 0 to 20 m. All studies evaluated agree that an optimal recovery time is between 4 and 12 min after the weighted sprint, which is observed in the findings of [47].

In this regard, Winwood et al. [31] analyzed the acute potentiating effects of heavy sled pulls on sprint performance with experienced rugby players. They used two sled load conditions (75 and 150% of body mass) to determine whether sled load influences the potentiation response and which sled load and rest interval may be optimal for obtaining a PAP effect (at 4, 8, and 12 min after endurance sprint). The main findings showed that the 75% load significantly improved 15 m sprint times after 12 min of recovery, which matches the influence of recovery time on post-activation potentiation in professional rugby players [54,55]. Loads of 125 and 150% of body mass produce no beneficial effect on PAP and cause a loss of running mechanics [30,31]. In addition, a 55% decrease in velocity has a negative effect on movement mechanics, leading to a negative effect on fatigue, and inhibits peak performance capacity [47].

On the other hand, the performance of the athlete in sprint actions can be benefited after the execution of plyometric exercises, always with adequate recovery time and whether or not an additional load is used during the plyometric exercise. Turner et al. [56], in their study on PAP using a polymetric exercise of jumping alternating legs using body mass (plyometric) and body mass plus 10% (weighted plyometric), found that using the athlete's body mass plus 10% led to improvements in sprint performance. In this sense, it must be taken into account that PAP is a highly individualized phenomenon, so it can be influenced by many factors such as the volume and type of load [57,58], in addition to the characteristics of the athlete [17], among other aspects.

4.3. Acute Effect on the Sprint's Kinematics and Kinetics

The acute effect on running kinematics and kinetics is another consequence of weighted training, so the loads used represent other variables to be taken into account when determining their application on athletes. Although research claims that this type of weighted training benefits the strength of the lower extremities by increasing the sprint performance, there is concern that overload work has negative influences on the acceleration kinematics, reducing the athlete's performance [22], or on the kinematics of movement, modifying the optimal angles of the joints during the application of force, application of horizontal force [20], and muscle activation [49].

As for the percentage of additional load, studies confirm that the heavier the additional load, the greater the interruptions in muscle activity [19], the greater the increase in the alteration of the muscle activation patterns of the lower extremities [48], and, consequently, the greater the changes in running technique [33]. In this regard, Pareja-Blanco et al. [33] state that lighter sled loads (<40% BM) appear to be more suitable for improving speed capacity without causing drastic changes in the unloaded sprint technique, while heavier loads may be more suitable for optimizing horizontal force production and therefore acceleration performance, especially in the first steps. In addition, it should be noted that loads less than 30% BM are optimal loads for sprint training without causing major interruptions in running technique (contact and flight time, stride length and frequency, and trunk angle) [19].

Studies with football, rugby union, and Australian football athletes concluded that RS training with loads close to 10% of body mass ensures that the acceleration kinematics are not negatively affected while improving the application of power in a horizontal direction [40]. On the other hand, in terms of velocity reduction, it is established that a reduction of 30% can cause an alteration in running mechanics, although it can produce beneficial effects in the first steps of the acceleration phase, as found in their study by [19].

Regarding the training weighted with different implements or different anchor points of the harness, the studies show that depending on the use of one or the other system, an alteration of the factors of the kinematic parameters is observed. On the one hand, the anchor point that causes the least alteration of the kinematics parameters of the sprint is the waist [20]. On the other hand, Martínez-Serrano et al. [48] found that sprint work with resisted parachutes did not change the kinematic or the muscle activation, despite producing a loss of speed, while the increase in the load of the sled thrust caused interruptions in the sprint technique and altered the muscle activation patterns of the lower extremities. Consequently, all these aspects can help determine the choice of the most suitable load in the resisted sprint job as well as the use of the right implement.

Finally, at the beginning of the study, it was hypothesized that the resisted method would produce improvements in sprint performance as well as benefits in PAP, which has been corroborated, provided that a 6-week training period is applied and appropriate overloads (% of body mass) are used.

4.4. Limitations and Recommendations

The results obtained in this systematic review should be treated with caution, and the limitations of this review should be taken into account. Firstly, a meta-analysis was not conducted, so the results of the included studies were interpreted qualitatively; secondly, the resisted method in sprinting comprises several variables, so it must be taken into account which of them are to be studied, as they cause different effects on sprint performance; and thirdly, a larger research sample size could provide greater statistical power to the results obtained.

On the other hand, the characteristics of the subjects in the studies analyzed do not comprise the same level of sports professionalism, which may lead to a fluctuation in the effects produced on sprint performance. Another limitation of this review is the lack of studies characterizing specific loads to improve the resisted method in sprinting according to its different dimensions. In addition, it should be noted that the analysis of the methodological quality of the studies included in the review conducted indicated that there were numerous studies with a risk of medium bias, which should be taken into account in the interpretation of the results. Thus, more research is needed to study the different combinations of loads to be used to improve the different sprint variables. In addition, studies are needed to provide a single unit of measurement for overload in the resisted method according to the benefits they are looking to obtain for their rugby players.

However, the results obtained in this review are applicable to rugby players, as the characteristics of these athletes were specifically analyzed. Future research could address the different variables of weighted loads quantification and unify them by seeking to establish a single unit of measurement. In addition, future research should look at the effects of resisted training on player positions.

5. Conclusions

In conclusion, the studies analyzed show that the resisted method produces three effects on rugby players to be considered: (1) To evaluate the potential improvements in sprint performance, it is necessary to carry out training plans between 6 and 8 weeks with weekly sessions of at least one hour in length. (2) If the aim is to improve the acute post-activation potentiation effect (PAP), the load to be applied is 75% of body mass or 30–35% of velocity reduction, with extended breaks ranging from 4 to 12 min depending on the condition of the athlete. (3) Effects produced on the kinematics and kinetics of running. If the aim is to work on horizontal strength performance by improving power and propulsion in the first steps of acceleration, loads should be 55–60% of body mass and 20–30% of velocity reduction. In all cases, for best results, subjects should have prior experience with working with resisted methods to improve sprint performance.

6. Practical Applications

It is very important for coaches, sports training specialists, and researchers to understand that programming weighted training and its application to rugby players is not the same for all sports [19]. Normally, two ways of programming weighted training are used: one, according to the percentage of body mass [42], although the load can also be programmed through the percentage of velocity reduction [20]. After identifying the type of load to be used on the target population, it is important to provide an adequate break of 4–12 min between each stimulus to avoid fatigue that negatively influences the players' performance [47].

Depending on the intended effect, the practitioner must choose the appropriate working methodology: (1) Adaptation to short-term training: work over a span of 12–16 sessions to improve acceleration phase and work on maximal velocity using light loads [40–43,45,46,49,50]. (2) Acute effects: working on specific situations of sprint performance, causing modifications in athletes' running both in propulsion and in the horizontal force applied in the first steps of the start [19,20,30,31,33,44,47,48].

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