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Classic Powerlifting Performance: A Systematic Review

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Abstract

Ferland, PM and Comtois, AS. Classic powerlifting performance: A systematic review. *J Strength Cond Res* XX(X): 000–000, 2019—The purpose of this study was to review all scientific publications related to able-body drug-tested classic powerlifting performance since January 1, 2012, and to regroup them into a brief narrative review. Three electronic databases were systematically searched in August 2018 using the wildcard: powerlift*. A manual search was performed from the reference list of all retained articles. The search and selection strategy permitted to gather a total of 16 scientific articles published in peer-reviewed journals. Results show that practitioners should prioritize a low-bar squat and a wide grip bench press because they generally contribute to moving greater loads, bring more attention to preventing injuries, since a fair amount of powerlifters seem to train injured and prioritize a hypertrophy-power-strength model when prescribing 3 times a week daily undulating periodization on nonconsecutive days for squat and bench. Practitioners could also introduce respiratory muscle training, use daily 1 repetition maximum training combined with down sets on experienced athletes and use a rate of perceived exertion scale based on repetitions in reserve combined with an individual velocity profile when prescribing intensity. Before competition, powerlifters seem to taper in this order: the deadlift, the squat, and lastly the bench press. The Slingshot does help to move more weight because it helps to generate more inertia, but it also deactivates the triceps. Finally, the present work was limited by the present literature but could serve as a reference in the field of powerlifting. Further research should include more details about the circumstances under which they were conducted.

Key Words: athletic profile, strength, resistance training, back squat, flat bench press, deadlift

Introduction

Powerlifting is a sport of relative and absolute maximal strength that includes 3 events: the squat, the bench press, and the deadlift. Participants have 3 attempts in each event to lift a maximal load in a single repetition while respecting judging criteria. For the squat event, the lifter can start his descent after receiving the chief referee's "squat" command. His squat has to reach legal depth, meaning the top surface of his leg closest to the hip joint has to go lower than the top of his knee before he starts his ascent, and his lift is completed once his knees reach full extension and he receives the "rack" command. When executing the bench press, the lifter has to wait for the chief referee's "start" command before he begins lowering the weight and stabilizes it when it makes contact with his chest or abdominal region. The lifter will then receive the "press" command for him to press the weight up until both of his arms reach full elbow extension before receiving the "rack" command. During the deadlift, the lifter can start lifting the weight as soon as the chief referee's arm is in the air; he then has to be able to stand in a full erect position and stabilize the weight at the top before he gets the "down" command and brings the bar down in a "controlled" manner. Failure from the lifter to execute any of the 3 lifts according to the technical rule book will result in the referees not accepting the lift. Three referees are in charge of judging each lift. Only 2 of the 3 need to approve the lift's execution for it to be accepted as "good." The lifter's best attempt from each event is then summed to yield an overall score (total), which determines the top 3 finishers from each weight class (3,9). Afterward, the competitor's body mass, which was taken at the official weigh-in 2 hours before the start of the competition, and his total are then entered into validated Wilks coefficient formula to determine the overall winner, best pound for pound lifter, regardless of the weight class (27).

The first official American national powerlifting championship was organized by the Amateur Athletics Unions (AAUs) in 1965. Years later, in November 1972, the International Powerlifting Federation (IPF) was founded. The next year, in 1973, the first official IPF World Championships were hosted, in Harrisburg, USA. At that time, the use of a belt (10 cm wide), wrist, and knee wraps was permitted and sanctioned (3). Within a year, the first supportive squat suits were created by the now-former world champion, Larry Pacifico, while during that same period bench shirts were being designed by former powerlifter and many times world record holder, John Inzer. Although most powerlifters competed with the help of performance enhancing gear (PEG), some purist powerlifters believed the sport was allowing the use of too much of it. As a result, the first Raw National Championship was held and sanctioned by the AAU in 1996. Years later, in 2008, the USA Powerlifting (USAPL) sanctioned their first raw nationals with 89 competitors. Fast-forward a few years later, in 2015, and the same championship hosted 1,147 competitors, a more than 12-fold increase in a 7-year span (26).

As of today, powerlifting has 2 distinct divisions: classic, commonly known as raw, and equipped. In the IPF's classic powerlifting division, the major permitted PEGs are a lifting belt, knee sleeves, and wrist wraps. In the equipped division, competitors are also permitted the use of squat suits, knee wraps, bench shirts, and deadlift suits (4,9). The use of knee wraps is permitted for raw lifting in some of the other federations and is

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mentioned when compiling records. The first official international classic powerlifting event sanctioned by the IPF was the World-Cup Classic Powerlifting Championships 2012 held in Stockholm, Sweden from June 12 to 17 (3).

At the time this theoretical research was initiated, no scientific reviews had been previously published on classic powerlifting. The only systematic review that had been published on the sport of powerlifting was aimed toward injuries, included weightlifters, and did not make any distinction between the classic and the equipped divisions (1).

The hypothesis of this theoretical research was that by using a systematic approach, authors would be able to review the different articles related to drug-tested classic powerlifting performance since January 1, 2012, and regroup them into a brief narrative review. It was anticipated that this work would gather information about powerlifter's characteristics, validated training protocols, and the powerlifting events. The overall objective of this study was to present guidelines for strength and conditioning specialists and powerlifting coaches working with drug-tested classic powerlifters.

Methods

Experimental Approach to the Problem

This theoretical research was conducted after the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (20). Three of the 4 electronic databases suggested by the University of Quebec in Montreal (UQÀM) library services were systematically searched in August 2018. These 3 databases were PubMed, SCOPUS, and SPORTDiscus. The database ERIC (ProQuest) was discarded because it is mainly used in the education field and is usually recommended for exercise science investigations directed toward physical education. The wildcard powerlift* was used to gather articles that included the words powerlifting and powerlifter.

The search in PubMed was made with the following strategy: (powerlift [All Fields] OR powerlifter [All Fields] OR powerlifter's [All Fields] OR powerlifters [All Fields] OR powerlifters' [All Fields] OR powerlifting [All Fields]) AND ("2012/01/01"[PDAT]: "3000/12/31"[PDAT]). The search in SCOPUS and SPORTDiscus was made in titles, abstracts, and key words. The search strategy was directed toward articles published as of January 1, 2012, or more recent since Classic powerlifting was recognized and sanctioned by the IPF during that year (3). Earlier articles would have been misleading; since before 2012, there was little to no differentiation made between classic and equipped lifting, and most of the nonequipped lifting was performed in non–drug-tested federations.

Duplicates. All duplicate articles were discarded by placing titles in alphabetical order in EndNote (version X7.4).

Language Barrier. If authors could clearly identify that the article was not written in English, the article was discarded.

Title and Abstract. If by reading the title or the abstract, authors could clearly identify that the article was not related to drug-tested classic powerlifting performance and directed on able-bodied powerlifters, and the article was discarded.

The decision to exclude all equipped and non–drug-tested publications was taken to make sure that results were applicable to classic drug-tested powerlifters. Previous research has shown that PEG does help increase performance (26), and that testosterone helps increase fat free mass, muscle size, and strength in normal men. This decision was made although studies directed on testosterone have always followed low-dosage protocols and results have never been generalized to athletes after mega-dose regimens (9,19).

Text. When reading text, the authors first identified if the article was a scientific article that came from a peer-reviewed journal, then went on to verify whether the study was related to performance, then went on to verify whether it was conducted on able-bodied powerlifters participating in the classic division or if the study was conducted under classic powerlifting standards, then to verify whether the participants were drug-tested or competed under a drug-tested IPF-affiliated federation.

Manual Search. A manual search was performed from the reference list of all articles retained from the systematic selection process.

Subjects

There were no restrictions set on the types of study design eligible for inclusion. If publication was not a scientific article published in a peer-reviewed scientific journal, the article was discarded. Therefore, conference papers, keynotes, and other articles were discarded.

If the investigations were directed toward the squat, the bench press, the deadlift, or powerlifting but were not directed on competitive powerlifters, the article was discarded. This decision was taken, so that all studies presented would have been directed on participants with a certain level of technical abilities. Studies directed on experienced resistance training subjects would not guarantee a high enough level of technical skills to assume that results would be transferable to powerlifters. There was no approval required for this brief narrative review as it is theoretical research.

Characteristics. A study that analyzed results from the USAPL (21,963 individuals between January 1, 2012, and June 11, 2016) showed that there was a statistical difference between classic and equipped lift results because of the extra PEG allowed for the squat and the bench press, but not for the deadlift. Table 1 presents median and maximal values (Max) per weight class for the classic division (4). These numbers are of interest to report, since American powerlifters have been very successful in international events over the last few years (3).

A published case study presented the following physical characteristics on the world's strongest drug-tested classic powerlifter: 30 years of age, height of 1.84 m, body mass of 183.1 kg, body mass index of 54.1, body fat (BF) of 24.3%, fat free mass of 138.6 kg, skeletal muscle mass of 58 kg, and skeletal mass index of 17.2 kg/m^2. His vastus lateralis thickness was of 4.2 cm, its fascicle length was of 8.2 cm, and its pennation angle was of 30°, which was reported to be a greater pennation angle than what was previously reported in other heavyweight powerlifters. At the time of the publication, this powerlifter was the current world record holder for the squat (477.5 kg), the deadlift (392.5 kg), and the total (1,105 kg) (2).

Another study compared respiratory muscle strength, diaphragm thickness, and pulmonary function (spirometry) between 10 world-class male powerlifters (7 with world titles and 3 with world records, age 28.0 ± 11.3 years, height 1.75 ± 0.5 m, body mass 100.7 ± 24.8 kg, BF 24 ± 10%) and a control group of 10 untrained individuals matched for age, stature, and body mass. Respiratory muscle strength was superior in powerlifters as

maximal static volitional inspiratory mouth pressure was 22% greater ($p < 0.05$, effect size: $d = 1.13$), and maximal static volitional expiratory mouth pressure was 16% greater ($p = 0.07$, effect size: $d = 0.86$). Diaphragm thickness was 27% ($p < 0.01$) greater in powerlifters and was correlated with competition total ($r = 0.825$, $p = 0.003$). There were no differences in pulmonary function outcomes measured with maximal flow volume loops (5).

An additional study examined muscle characteristics and microRNAs (miR) expression, which are a category of short noncoding RNAs that promote gene expression (6), using muscle biopsies from the vastus lateralis of 15 national-level Norwegian powerlifters (25.1 ± 5.8 years) and 13 recreationally active students as controls (24.1 ± 2.0 years). Muscle strength measured by isokinetic knee extension showed that powerlifters were stronger ($p < 0.001$) than the control group even when controlled for body size ($p < 0.001$). The powerlifters when compared with control also had a smaller type 1/type 2 fiber ratio (0.8 ± 0.3 vs. 1.1 ± 04, respectively, $p = 0.022$), larger type 1 and type 2 fibers ($p < 0.001$), and a larger area of type 2 fibers per satellite cell ($p = 0.007$). Of the 7 myomiRs studied, 2 were similarly expressed in both groups: miR-208a ($p = 0.71$) and miR-208b ($p = 0.496$); 4 were lower in the powerlifter group: miR-486 ($p = 0.003$), miR-499a ($p = 0.012$), miR-133a ($p < 0.001$), and miR-1 ($p = 0.008$); and 1 was more elevated: miR-206 ($p = 0.009$). Muscle mass regulators were all higher in powerlifters: HDAC4 ($p = 0.001$), MyoD ($p = 0.011$), MyoG ($p = 0.002$), myostatin ($p < 0.001$), PAX3 ($p = 0.008$), PAX7 ($p < 0.001$), SRF ($p < 0.001$), and SOX6 ($p = 0.008$), whereas PTEN concentration showed no statistical difference between groups ($p = 0.302$). There was also no statistical difference for the catabolic gene FOXO1/3 ($p = 0.244$, $p = 0.213$) between groups, whereas MuRF1 ($p = 0.013$) and Atrogin1 ($p = 0.004$) were of higher abundance in powerlifters. MicroRNAs miR-23a ($p < 0.001$) and miR-23b ($p < 0.001$), which inhibit catabolic gene expression were also more elevated in powerlifters. Furthermore, microRNAs miR-15a ($p < 0.001$) and miR-16 ($p = 0.016$) were more elevated in powerlifters, which both have been shown to have an inhibition effect on the formation of new blood vessels through vascular endothelial growth factor ($p = 0.064$), which was almost more abundant in powerlifters. As well, microRNAs miR-451a ($p = 0.017$) and miR-30b ($p = 0.013$) expression were more elevated

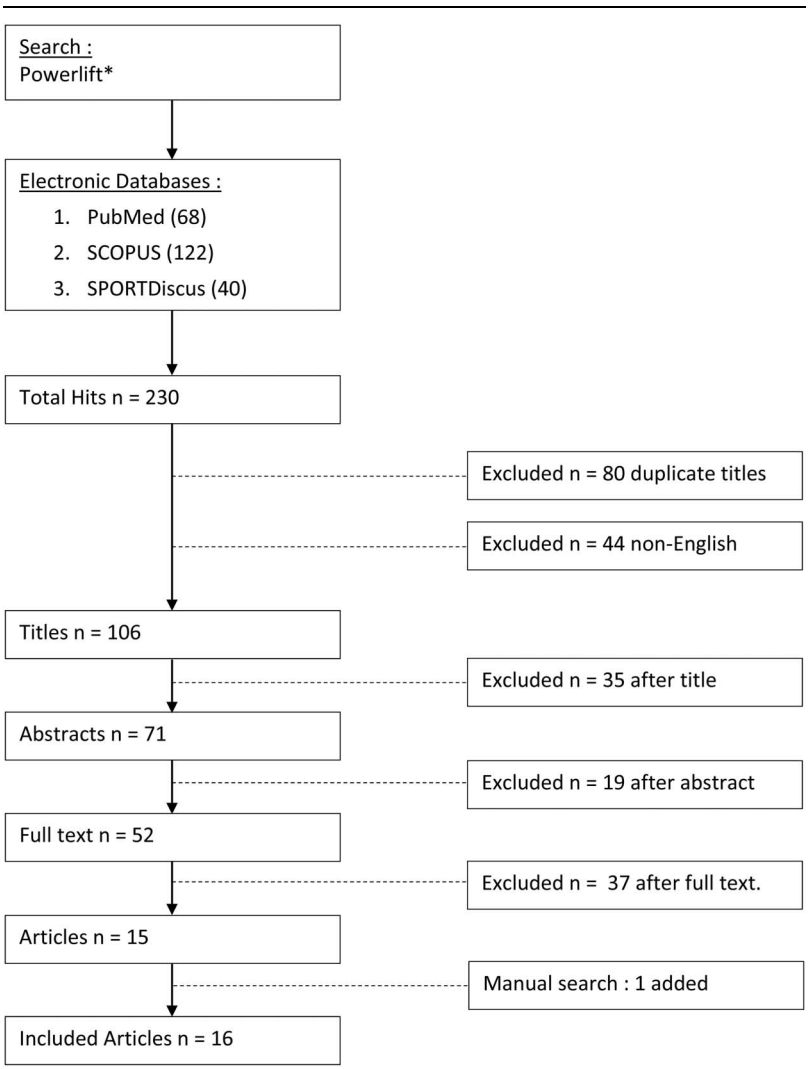

Figure 1. Flow diagram of the search strategy and article selection process.

Table 1
Median and max per classic powerlifting weight class.*†

		Squat		Bench		Deadlift	
	Weight class (kg)	Median (kg)	Max (kg)	Median (kg)	Max (kg)	Median (kg)	Max (kg)
Women	−47	73	123	40	68	96	170
	−52	85	152	48	80	108	158
	−57	93	165	53	95	115	204
	−63	95	163	55	142	123	221
	−72	105	183	60	118	130	243
	−84	108	200	60	118	135	230
	84+	120	273	68	150	143	238
Men	−59	93	236	58	143	120	255
	−66	143	243	93	170	173	268
	−74	159	258	108	193	193	283
	−83	173	306	118	206	208	320
	−93	188	340	128	268	225	374
	−105	200	313	138	275	233	363
	−120	215	376	145	251	240	372
	120+	228	426	155	266	245	383

*Max = maximum.
†Adapted from Ball and Weidman (4).

in powerlifters, whereas Cyclin D1 ($p = 0.198$), miR-145 ($p = 0.730$), and SPRED-1 ($p = 0.083$) showed no difference between groups, whereas miR-126 ($p < 0.001$) and cyclin D2 ($p = 0.019$) had lower expression in powerlifters compared with controls. A discriminant analysis revealed that the combination of the 5 microRNAs, miR-126, miR-3b, miR-16, miR-23a, and miR-15a, classified correctly all participants into their respective group (powerlifters and control) (7).

Procedures

Classification of the retained articles was performed by regrouping them by topics after screening the text. The weight of the search was placed on descriptive and quantitative results that were related to performance in classic powerlifting. In addition, several studies have been directed on both sexes (male and female) and on different levels of athletes. Therefore, the sex and the level of the athletes are mentioned when summarizing study results.

Titles, abstracts, and full texts coming from studies gathered through the systematic and the manual search were screened independently by the 2 reviewers to identify studies that potentially met the inclusion criteria. Any disagreement between the 2 reviewers over the eligibility of particular studies would have been resolved through discussion with a third reviewer.

The authors did take time to contact corresponding authors from 16 articles retained after abstract screening for missing information as the authors did not specify in their methodology if their study was conducted on classic powerlifting or drug-tested powerlifters. The correspondence authors were contacted a minimum of 2 times by e-mail and once through the researchgate website. All other retractable authors were contacted at least once by e-mail and once through researchgate.

Results

A total of 230 titles came out of the initial database search. Of those 230, 80 were removed because they were duplicates and 44 were removed because they were not published in English. Therefore, 106 titles were left for screening. Of those 106 titles, 35 were discarded because they did not match the eligibility criteria. Consequently, 71 abstracts were read and another 19 studies were discarded, leaving 52 articles for detailed reading. Of the 52 articles, 5 were discarded because of poor quality, 1 was discarded because it was not related to performance, 1 was discarded because it was not conducted on powerlifters, 20 were discarded because they were not conducted on classic powerlifting, 6 were discarded because they were not conducted on drug-tested athletes, and 4 were discarded because the authors did not mention the information necessary to meet our inclusion and exclusion criteria and did not respond when contacted. The systematic search and the manual search yielded a total of 15 publications containing suitable results plus 1 article that was added from the manual search. As a result, literature summary includes 16 scientific articles published in peer-reviewed journals by 13 different first authors between 2012 and 2018. Efforts directed toward contacting authors for missing inclusion/exclusion criteria information were rewarding because 6 articles from the 16 studies contacted met our criteria. The article selection process is outlined in Figure 1.

Programming

A case study was reported on 2 competitive powerlifters from the USAPL, both with 10 years of training experience, that performed 37 consecutive days of 1 repetition maximum (1RM) squat training. The training protocol had them max out on squats then execute 5 down sets at either 5×3 at 85% or 5×2 at 90% of their daily 1RM, alternating down sets each day from day 1 to 35. On day 36, they did 1×1 at 85% of day 1 1RM, and on day 37, they maxed out again. The first powerlifter had a +5 kg (2.3%) increase on his 1RM from day 1 to day 37. His peak increase was reached at day 35 with a +12.5 kg (5.8%) increase on his 1RM and a +8.02 pts (5.5%) increase on his Wilks points. The second powerlifter had a +21 kg (9.5%) and a +12.02 pts (9.2%) increase on his 1RM and on his Wilks points from day 1 to day 37, which was his highest peak increase for both. This case study demonstrates that a daily-squat 1RM followed by down sets can increase 1RM in experienced powerlifters, although Figure 1 presented in the original study showed that the athletes' performance varied from day to day (29).

Another study that focused on programming was directed on 18 collegiate male powerlifters that composed 2 groups

comparing 1RM strength gains in the squat, the bench, and the deadlift in 2 daily undulating periodization (DUP) models. Both groups trained 3 times on nonconsecutive days for 6 weeks. The first group trained under a traditional DUP model, doing hypertrophy on the first day, strength on the second, and power on the third (hypertrophy, strength, and power). The second group trained under a nontraditional DUP model training for hypertrophy on the first day, power on the second, and strength on the third (HPS). Both groups executed the same number of sets and reps (Table 2). Squat and bench were performed during each training session, and deadlift was only performed during the strength sessions. Squat and deadlift increases were not significantly different between groups ($p > 0.05$), but bench press increase was significantly greater ($p < 0.01$) for the HPS. Effect size for the 1RM in the squat ($d = 0.74$), the bench press ($d = 0.52$), the total ($d = 0.51$), and Wilks ($d = 0.67$) were all in favor of HPS (Table 3). Training protocols and 6-week increases are presented in Tables 2 and 3 (30).

Two other studies interrogated powerlifters on their tapering practices using semistructured interviews. The first was directed on 11 (8 men and 3 woman) New Zealand powerlifters (28.4 ± 7.0 years, Wilks 431.±43.9 pts) (22) and the second on 10 (6 men and 4 women) open-class (age 29.2 ± 3.2 years) Croatian powerlifters (Wilks 355.1 ± 54.8 pts) (14). A summary of their tapering practices is presented in Table 4.

Rated Perceived Exertion

Three recent articles published by Helms were directed on powerlifters and targeted toward the resistance training rated perceived exertion (RPE) scale based on repetitions in reserve (Table 5). His first study presented a significant relationship ($r = 0.88$ to 0.91, $p < 0.001$) between intensity (% of 1RM) and the reported RPE in each lift. This study would have subjects that execute sets up to a 1RM and rate their RPE for each set. The average concentric velocity of each lift had a significant inverse relationship with the RPE ($r = -0.79$ to -0.87, $p < 0.001$) and with the 1RM intensity ($r = -0.90$ to -0.92, $p < 0.001$). This study concluded that the RPE scale could be a useful tool when training powerlifters and prescribing intensity on the "big 3" (squat, bench press, and deadlift) but recommended that an individual velocity load profile should be developed (17).

Helm's second study verified the subject's ability to select loads when performing working sets. The powerlifters trained 3 times a week on nonconsecutive days for 3 weeks after a hypertrophy-power-strength (HPS) DUP program. Subjects trained the squat and the bench press on all 3 days and the deadlift only on power and strength days. Absolute mean difference between reported RPE from lifters and target RPE prescribed by training protocol was of 0.33 ± 0.28 RPE while difference between reported RPE and target RPE ranged from 0.00 to 1.33. The result tables indicate that target RPE seems harder to reach during power days. From this study, Helms concluded that powerlifters can accurately select weight for a prescribed RPE, and that RPE accuracy was better when closer to failure (15).

In the third study by Helms, a validation of a training method named RPE stop was performed. The protocol followed a DUP program. Monday: squat and bench hypertrophy (sets of 8 reps at RPE 8), Wednesday: squat, bench, and deadlift power (sets of 2 reps at RPE 8), and Friday: squat, bench, and deadlift strength (sets of 3 reps at RPE 9). Subjects had to reach a first top set; if RPE of the top set was lower than prescribed RPE, subjects had to perform a second top set (with a maximum of 2 top sets). Subjects would adjust the weight with this formula: 0.5 RPE = 2% of 1RM. After top set/sets were performed, subjects had to complete back-off sets at an RPE stop percentage set between 94 and 98% of top set weight if RPE set was reached; if RPE was not reached during top set, subjects would adjust back-off sets weight to hypothetical top set weight. Back-off sets would go on until target RPE was reached or surpassed, with a limit of 8 back-off sets. A mandatory 3-minute rest period was performed in between all sets. The authors concluded that volume could effectively be autoregulated with the RPE stop method (16).

Table 2
Training protocol of the daily undulating periodization.*†

Week	Hypertrophy	Power	Strength
1	5 × 8 at 75% of 1RM	5 × 1 at 80% of 1RM	3 × max at 85% of 1RM
2	5 × 8 at 75% of 1RM	5 × 1 at 80% of 1RM	3 × max at 87.5% of 1RM
3	4 × 8 at 75% of 1RM	4 × 1 at 85% of 1RM	3 × max at 90% of 1RM
4	4 × 8 at 75% of 1RM	4 × 1 at 85% of 1RM	3 × max at 90% of 1RM
5	3 × 8 at 75% of 1RM	3 × 1 at 90% of 1RM	3 × max at 92.5% of 1RM
6	3 × 8 at 75% of 1RM	3 × 1 at 90% of 1RM	3 × max at 95% of 1RM

*1RM = 1 repetition maximum.
†Adapted from Zourdos et al. (29).

Table 3
Percent increase in performance for daily undulating periodization.*†

	HSP (%)	HPS (%)
Squat	7.93	10.48
Bench	2.71	8.13
Deadlift	6.70	7.57
Total	6.70	8.66
Wilks	6.76	8.65

*HSP = hypertrophy, strength, and power; HPS = hypertrophy, power, strength.
†Adapted from Zourdos et al. (29).

Table 4
Tapering practices of New Zealand's and Croatia's powerlifters.*†

	New Zealand	Croatia
Training frequency	4.8 ± 0.5	4 ± 1
Squat frequency	—	2.1 ± 0.6 times/wk
Bench frequency	—	2.3 ± 0.5 times/wk
Deadlift frequency	—	1.1 ± 0.3 times/wk
Total volume peak	5.2 ± 1.7 wks	4.5 ± 1.8 wks
Intensity peak (% of 1RM)	1.9 ± 0.8 wks	8 ± 3 days out
Heaviest session	2.3 ± 0.7 wks	7 ± 1 days out
Removal of S and D accessory	2.0 ± 0.7 wks	—
Removal of B accessory	1.9 ± 0.7 wks	—
Taper length	2.4 ± 0.9 wks	18 ± 8 days
Taper volume reduction	58.9 ± 8.4%	50.5 ± 11.7%
Final week frequency reduction	34.7 ± 14.2%	47.9 ± 17.5%
Final heavy squat session (d)	8.0 ± 2.9	7 ± 1
Final squat session (d)	4.0 ± 1.8	4 ± 2
Final heavy bench session (d)	7.3 ± 2.7	6 ± 2
Final bench session (d)	4.0 ± 1.8	3 ± 1
Final heavy deadlift session (d)	10.9 ± 4.0	8 ± 2
Final deadlift session (d)	7.4 ± 4.1	4 ± 3
Final training session (d)	3.7 ± 1.6	3 ± 1

*1RM = 1 repetition maximum; Wks = weeks out of the competition; Days = days out of the competition.
†Adapted from and Pritchard et al. (22) and Grgic and Mikulic (14).

Table 5
Rating of perceived exertion (RPE) scale for powerlifters.*†

Rating	Description
10	Max effort
9.5	Could increase load
9	1 rep remaining
8.5	1–2 reps remaining
8	2 reps remaining
7.5	2–3 reps remaining
7	3 reps remaining
5–6	4–6 reps remaining
3–4	Light effort
1–2	Little to no effort

*Rep = repetition.
†Adapted from Helms et al. (17).

Squat

A study compared 6 powerlifters performing low-bar back squats to 6 Olympic weightlifters performing high-bar back squats. Both trained in their respective assigned style. Results of this study presented that, on average, greater loads were lifted with the low-bar back squat. The authors concluded that the low-bar back squat could be preferable for lifting more weight, and it could be used to target the stronger hip musculature (11).

Bench

Two studies were conducted to compare bench press grip width with IPF standard execution of the lift (10), with the exception that participants were allowed to touch and go without bouncing. The first study was conducted on 12 male bench press national record holders and measured the effect of grip width at $1 \times 95\%$ and $1 \times 100\%$ of 1RM (13). The second study was conducted on 12 healthy bench press athletes competing at national and international levels performing a 6RM (23). The best successful attempt in both studies were significantly higher ($p \leq 0.029$, $p \leq 0.001$) with a wider grip (131.5 ± 22.9 and 132.7 ± 17.0 kg), when compared with the medium (126.5 ± 21.6 or 125.4 ± 17.4 kg) or narrow grip (122.1 ± 19.4 and 119.2 ± 16.6 kg). All bench press grip widths presented similar lifting times in both studies ($p \geq 0.111$, $p = 0.357$–1.000), whereas the second study stated that the barbell traveled more distance when comparing the narrow with the wide grip ($p = 0.025$). The first study also showed that velocity was significantly higher ($p \leq 0.001$) when bench pressing with a narrow grip, which could explain the similarity in lifting times. The second study observed that the only significant difference observed in muscle activation was in the biceps brachii, which was significantly higher in the wide (25.9% $p = 0.040$) and medium grip (30.5% $p = 0.003$) when compared with the narrow grip, without any other significant differences in electromyography (EMG) activity from the pectoralis major, triceps brachii, anterior deltoid, posterior deltoid, and latissimus dorsi.

Mark Bell's Slingshot

Another study directed on 15 male powerlifters (age = 27.05 ± 5.94 years, body mass 94.15 ± 13.43 kg) examined the effect of the bench press elastic assistance device, the Slingshot, on velocity and neuromuscular activity using IPF-approved bench press equipment (10) adjusted to participants preferred rack height and grip width. The study protocol observed classic/raw sets of singles over 90% of 1RM with standard IPF referee commands (10) until 1RM was reached (3–5 attempts) and back-off sets of 1×3 at 87.5% and 3×8 at 70%. Participants then had a 7- to 14-day rest interval before returning to complete the same sets and reps scheme, but this time wearing the Slingshot device, with the exception that the participant's first 1RM attempt, would be their last 1RM raw attempt. All subjects had a higher 1RM when using the Slingshot (160.4 ± 4.43 kg $> 139.7 \pm 4.34$ kg). The authors alleged that the increase in performance was due to the increase in barbell peak velocity and presticking point velocity. Normalized triceps EMG, expressed in root mean square, was significantly higher in the classic than the Slingshot attempts through all sets and reps schemes, which indicated that the Slingshot unloads the triceps muscles (8).

Injuries

One study was directed toward injuries in powerlifting and was conducted by sending a questionnaire by e-mail to participants from the 2014 open-category classic division list from the Swedish Powerlifting Federation. The top 25% Wilks score was excluded to make results more generalizable. Results were compiled from 104 powerlifters (51 men and 53 women) who answered the questionnaires (Table 6). From those questionnaires, 87% of the participants testified that they had experienced an injury in the past 12 months, and 70% of them reported to be currently injured. Out of those that reported to be currently injured, 49% reported 1 injury site and 47% reported 2 or 3 injury sites. Out of all powerlifters who reported injuries, 42% were injured during squat training, 27% during bench training, and 31% during deadlift training. As for those who were injured in competition, 3% were injured in the squat event, 4% were injured in the bench event, and 7% were injured in the deadlift event. Most powerlifters that reported an injury had altered their training routine and 16% had completely stopped training. Out of the injured subjects, 23% of them believed that they were injured because of excessive training volume and/or intensity, 6% believed it was because of poor technique, and 6% believed it was due to poor mobility (25).

Discussion

One of the main findings that came from the systematic search is that a fair amount of the methodologies from the published articles were incomplete and did not pay attention to the specific knowledge of the sport. There were many articles that did not

Table 6
Reported injuries (percentage by location).*†

	Current injuries		Past 12 mos	
	Women, $n = 35$	Men, $n = 36$	Women, $n = 43$	Men, $n = 40$
Neck	20%	—	16.3%	—
Shoulder	25.7%	33.3%	39.5%	32.5%
Thoracic area	28.6%	—	25.6%	—
Lumbopelvic area	22.9%	41.7%	30.2%	40%
Hip	25.7%	30.6%	34.9%	20%
Knee	—	16.2%	18.6%	27.5%
Thigh	17.1%	—	—	17.5%

*Note that each participant may have recorded more than one injury.
†Adapted from Strömbäck et al. (25).

specify in what discipline their subjects were competing in (classic or equipped), if they had competed in a drug-tested federation or if they were drug-tested during the investigation, and if a negative result was an eligibility criteria. Hence, authors should be aware of the reality of the sport they are studying and include more details in their methodology. Nonetheless, this current review was able to regroup results from all studies published on classic drug-tested powerlifting into one narrative article.

Outcomes presented from the USAPL (4) should be considered when training athletes to set goals and make them as competitive as possible, it could be valued to put these numbers in relationship with performance. As for the case study that was performed on body composition (2), it could be relevant to study the relationship between body composition and performance. The research directed on respiratory muscle strength showed that powerlifters had stronger respiratory muscles and stated that this could help prevent spinal injuries (5). A special attention could be brought to these muscles as respiratory muscle strength and endurance can be improved with airflow resistive-type training (21). Muscle characteristics and microRNA were able to characterize the powerlifter phenotype (7); however, further additional research could be directed toward elite powerlifters.

Daily 1RM combined with down sets could be used to increase the squat 1RM (29), although a complete study could be directed toward a bigger group of technically advanced squat athletes to make results more plausible. The DUP model suggested that HPS (30) seemed like a better approach, although research could be directed toward more advanced athletes or tried to improve training protocols or even compare this 3 times per week training protocol to a protocol with less frequency. Although tapering practices have been outlined (14,22), studies should be directed toward comparing different tapering practices to find which tapering practices are more useful.

Rated perceived exertion scale based on repetitions in reserve could be a useful tool when prescribing intensity (17) since powerlifters can accurately select weight from a prescribed RPE (15), and RPE stop could be used as a training method (16), although a velocity profile should be developed for the individual. It could have been interesting to present correlations between target RPE and % of 1RM.

Powerlifters should prioritize the low-bar squat as it can move more weight (11). A systematic review published on the comparison of both styles of squats suggested that practitioners looking to develop the posterior muscle chain of their athletes should focus on the back squat as greater muscle activity was shown in the glutes and the erectors spinae (12). A training emphasis should be performed on the wide grip bench press, as 2 studies published performance results in its favor (13,23), although these results should be taken in moderation, because another study not conducted on powerlifters found differently (28). One caveat, however, Mark Bell's Slingshot helps lift more weight because it accentuates the barbell's inertia, but it deactivates the triceps (8).

A special attention should be brought to injuries when training powerlifters as most of them appear to train injured (25).

Practical Applications

Strength and conditioning specialists and powerlifting coaches should be aware of what loads to aim for (4), prioritize a low-bar squat (11) and a wide grip bench (13,23), as they generally contribute to moving greater loads, pay attention to injuries in the sport since a fair amount of the participants appear to train injured (25), and prioritize an HPS model when prescribing DUP for squat and/or bench 3 times a week on nonconsecutive days (30) when training drug-tested classic powerlifters. They could also introduce respiratory muscle training (5), use daily 1RM training combined with down sets on experienced athletes (29), and an RPE scale based on repetitions in reserve combined with an individual velocity profile when prescribing intensity (15,17). Powerlifters seem to taper the deadlift first, then the squat and then the bench press (14,22). The Slingshot device does help to move more weight because it helps to generate more inertia, but it does deactivate the triceps (8).

In conclusion, by using a systematic approach, authors were able to review several articles published on classic powerlifting performance since January 1, 2012, and regroup them into brief a narrative review. Therefore, the hypothesis of this theoretical research is accepted. Further research directed toward powerlifting should always specify if athletes were drug-tested or if they competed in a drug-tested federation, as well as under what regulations the study was conducted, since it is now differentiated on the competitive scene. The present work was limited by what was published in the current scientific literature but could serve as a reference in the field of powerlifting, whether it would be when training athletes or conducting research. Finally, it is important to remember that even though results presented in this study all came from studies directed on drug-tested powerlifters, this does not necessarily mean that all subjects were drug-free as the undetected use of synthetic hormones has been a reality in sports for years (18), and drug testing has little influence on an athlete's decisions to use banned substances (24).

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