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Original citation:

Duncan, M, Guimarães-Ferreira, L, Tallis, J, Loturco, I, Weldon, A & Thapa, R 2023, 'Determining and comparing the optimum power loads in hexagonal and straight bar deadlifts in novice strength-trained males', Biomedical Human Kinetics, vol. 15, no. 1, pp. 229–238. https://doi.org/10.2478/bhk-2023-0027

DOI 10.2478/bhk-2023-0027
ESSN 2080-2234

Publisher: Sciendo

sciendo

Original Paper

Biomedical Human Kinetics, 15, 229–238, 2023
DOI: 10.2478/bhk-2023-0027

Determining and comparing the optimum power loads in hexagonal and straight bar deadlifts in novice strength-trained males

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Abstract

Study aim: This study aimed to determine and compare the 'optimum power load' in the hexagonal (HBDL) and straight (SBDL) bar deadlift exercises.

Material and methods: Fifteen novice strength-trained males performed three repetitions of the HBDL and SBDL at loads from 20–90% of their one-repetition maximum (1RM). Peak power, average power, peak velocity, and average velocity were determined from each repetition using a velocity-based linear position transducer.

Results: Repeated measures ANOVA revealed a significant effect of load for HBDL and SBDL (all $p < 0.001$). Post-hoc analyses revealed peak power outputs for HBDL were similar across 50–90% 1RM, with the highest peak power recorded at 80% 1RM (1053 W). The peak power outputs for SBDL were similar across 40–90% 1RM, with the highest peak power recorded at 90% 1RM (843 W). A paired sample t-test revealed that HBDL showed greater peak power at 60% (Hedges' g effect size $g = 0.53$), average power at 50–70%, ($g = 0.56–0.74$), and average velocity at 50% of 1RM ($g = 0.53$). However, SBDL showed greater peak velocity at 20% ($g = 0.52$) and average velocity at 90% of 1RM ($g = 0.44$).

Conclusion: Practitioners can use these determined loads to target peak power and peak velocity outputs for the HBDL and SBDL exercises (e.g., 50–90% 1RM in HBDL). The HBDL may offer additional advantages resulting in greater peak power and average power outputs than the SBDL.

Keywords: Muscle strength – Muscle power – Resistance training – Physical exertion – Athletic performance

Introduction

Strength is fundamental to sports performance and is extensively tested and trained across professional sports [24]. Strength development can be achieved through resistance training, which typically involves lifting heavy weights against gravity or moving light-to-moderate loads as fast as possible [6, 13]. In professional sports, the use of one-repetition maximum (1RM) and submaximal (e.g., 6RM) strength tests are commonly used to calculate individualized resistance training intensities [24, 25]. However, a limitation of these testing methods is that athletes' physical performance may fluctuate daily, and physical improvements (e.g., increases in maximal strength) can lead to previous assessment data becoming irrelevant and imprecise [1]. Therefore, applying appropriate training intensities remains challenging when designing and implementing resistance training programs [1].

These limitations have led to alternative methods, such as velocity-based training, which can accurately prescribe and monitor resistance training intensity in athletes in different contexts [1]. Furthermore, velocity-based training is more time efficient and less fatiguing when compared to traditional strength training methods, which are usually based on %1RM [16]. Velocity-based training also

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enables additional metrics to be assessed, including the ability to produce high levels of force at high velocities (i.e., power), which underpins numerous sport-specific activities (e.g., acceleration, deceleration, changing of direction, jumping) [15, 20]. Although various equipment is available to implement velocity-based training, linear position transducers are cost-effective and widely used [23]. Linear position transducers allow practitioners to obtain valid and reliable data regarding "bar-power", calculated as the product of bar-force and bar-velocity, which can be subsequently used to determine the "optimum power load" (OPL) (i.e., the load that maximizes power output) in a given exercise [5, 13].

Using the back squat for example, Loturco et al. investigated and recommended using the OPL instead of 1RM testing [16]. This is due to the OPL providing a more valid measure of true athletic potential as this loading range reflects the force and velocity applied to the barbell, at the same time, instead of only considering the maximum mass moved during a maximum effort [16]. Thus, the OPL may better reflect the abilities required in sporting actions where athletes must move their body mass or a sport-specific implement (e.g., tennis racquet, cricket bat, or javelin) at high speeds [13, 16]. Indeed, when prescribing individualized training loads, the OPL may provide superior physical benefits and transfer more effectively to sports performance (e.g., sprinting, jumping, and punching impact) [13]. Furthermore, the use of OPL applies to athletes across different playing levels, sports, age categories, and sexes [14, 17, 22]. However, coaches may not have access to linear position or linear velocity transducers (the gold standard method for determining the OPL) [13] due to various constraints (e.g., financial, access to specific facilities, and specialist equipment). Under these circumstances, defining the OPL based on 1RM data may be viable. As the OPL is likely exercise-dependent [19], it is important to investigate other common exercises to produce normative data.

One exercise used extensively across sports to develop strength and power performance is the deadlift [18, 21, 24]. Although various methods exist for performing the deadlift, the hexagonal bar deadlift (HBDL) and straight bar deadlift (SBDL) are commonly prescribed. Biomechanical assessments using 3-D motion analysis and force platform data from experienced powerlifters identified that the OPL derived from peak power outputs occurred at 30% and 40% 1RM for the SBDL (4388 W) and HDBL (4872 W), respectively [21]. Other research suggests that the OPL occurs at 50% 1RM for the SBDL (1462 W) [2]. The large differences between these peak power outputs derived from Swinton et al. [21], calculating only a single power value from a bar marker and ground reaction force data, and did not separate the bar, body, and system, like in work by Blatnik et al. [2]. The study by Swinton et al. [21] is the only evidence specifically comparing the OPL between the HBDL and SBDL. While the data [21] provides a useful model for strength and conditioning coaches, the use of sophisticated and costly equipment (i.e., force platforms) with trained powerlifters may limit the practical application of these findings to other populations (e.g., novice athletes). Moreover, the use of force platforms allows the calculation of system power instead of bar power [13], and the use of bar power is suggested for athletes that require the application of power to external implements or opponents, such as in basketball, rugby, or soccer [13].

Therefore, this study aimed to 1) determine the OPL in the HBDL and SBDL exercises in non-specifically trained athletes and 2) compare any differences in velocity and power outputs (i.e., peak and average) between the HBDL and SBDL. Based on previous findings [21], it was hypothesized that similar OPL and velocity profiles would be provided from the HBDL and SBDL. However, the HBDL will allow greater peak power outputs to be reached. These data are important for strength and conditioning coaches to provide informed decisions on the testing methods, resistance training intensity, and exercise selection of deadlift exercises when developing muscular power.

Materials and methods

A crossover, repeated measures design was used to collect data across four testing sessions, each separated by 72 hours. In the first two testing sessions, participants attended the laboratory and were familiarized with the equipment, exercise execution, and testing procedures, then underwent 1RM testing on the HBDL and SBDL in a randomized order. The third and fourth testing sessions required participants to perform the HBDL and SBDL at loads ranging from 20–90% 1RM (10% increments) in a randomized order [2]. Average velocity, peak velocity, average power, and peak power were subsequently calculated across each of the 10% load increments.

Participants

Fifteen male participants (age: 24.3 ± 2.1 yrs [age range: 21–29 yrs]; body mass: 82.3 ± 9.1 kg; height: 179.5 ± 7.8 cm; resistance training experience: 2.4 ± 0.6 yrs) participated in this study. Participants were engaged in ~12 hours of structured exercise per week and represented various sports teams (e.g., basketball, soccer, and rugby union, competing at the highest university standard in the United Kingdom). All experimental testing occurred within the pre-season preparatory period of participants' respective sports. A priori power analysis indicated that a sample size of 15 was needed for an effect size of 0.25 at 80% power with a p-value of 0.05.

Participants were requested to be well-hydrated and maintain habitual caffeine and dietary habits before all testing sessions. Furthermore, participants were required to refrain from exercise 24 hours before testing sessions. Adherence to these pre-test conditions was queried and confirmed by the participants before each testing session upon arrival at the laboratory. All testing took place between 9.00 am and 12.00 pm, and the timing of attendance at the laboratory between sessions was standardized for each participant. Participants were excluded if they had 1) muscle, bone, or joint injury that could impede their exercise performance; 2) a training experience of fewer than two years; or 3) no experience performing HBDL and SBDL exercises. Baseline participant characteristics are presented in Table 1. This study was approved by the university's Ethics Review Board and conducted following the Declaration of Helsinki. All participants provided written informed consent after reading a description of research procedures and were ensured the anonymity of data and identities.

Lifting procedures

All exercises were performed using a 20 kg hexagonal bar, with handles elevated above the plate, (Perform Better UK, Warwickshire, UK) and a 20 kg Eleiko bar (Eleiko Sport AB, Halmstad, Sweden) on an Olympic lifting platform (Pullum Power Sports, Luton, UK). All lifts followed previously published protocols [21]. Deadlifts were deemed successful if the barbell was not lowered at any point during the concentric phase, and upon completion of the lift, the body posture was erect, with the knees straightened and shoulders retracted. A hook grip was used in all cases with no use of lifting straps. A trained researcher was present during all testing sessions to ensure that any lift deviating from the correct technique was disregarded.

Testing protocol

Following a study brief, each participant attended the laboratory on four occasions. The first two sessions (performed in a randomized order) involved the correct deadlift techniques being demonstrated to participants before determining their 1RM on the HBDL and SBDL exercises. Participants' 1RM was determined according to methods outlined by Kraemer et al. [11], which were subsequently used to prescribe 1RM intensities (20–90%) undertaken during the experimental trials.

Table 1. Participant characteristics

Variables	Mean ± SD
Age [yrs]	24.3 ± 2.1
Height [cm]	179.5 ± 7.8
Resistance training experience [yrs]	2.5 ± 0.6
Body Mass [kg]	82.3 ± 9.1
1RM Hexagonal Bar [kg]	121.1 ± 20.3
1RM Straight Bar [kg]	108.1 ± 17.8

Note: 1RM – one repetition maximum, SD – standard deviation.

Before the submaximal testing on each testing occasion, participants performed a dynamic warm-up consisting of 4 sets of 8–10 repetitions on the deadlift at a load of 30% 1RM. In a randomized order (randomized by bar type), participants completed three repetitions of the HBDL and SBDL at each load from 20–90% of 1RM [2]. Participants were instructed to perform each repetition with maximal effort attempting to lift the load as fast as possible, following prior research guidelines [21]. A 3-minute rest period between repetitions and a 5-minute rest period between loads was provided to decrease the effects of cumulative fatigue. All deadlifts were performed with participants standing on an Olympic weightlifting platform, and power and velocity values were assessed using the TENDO Fitrodyne Weightlifting Analyzer V-207 (Tendo Sports Machines, Slovak Republic), which is highly reliable (ICC = 0.97) for assessing bar-power output [9] and is considered valid for the assessment of peak power [7]. The trial producing the greatest peak power was used for further analysis for each load.

Statistical analysis

Data are presented as mean and standard deviation. The normality of data was verified using the Shapiro-Wilk test. Intraclass correlation coefficients (ICCs) were calculated to assess intra-trial reliability with values <0.5 interpreted as poor, 0.5–0.75 as moderate, 0.75–0.9 as good, and >0.9 as excellent, based on the lower bound of the 95% confidence interval (CI; $ICC_{95\%CI\ lower\ bound}$) [10]. Repeated measures analysis of variance (ANOVAs) were used to examine differences in average power, peak power, average velocity, and peak velocity across the eight loads (20-90% 1RM) for the HBDL and SBDL. Where significant differences were detected, Bonferroni post-hoc multiple comparisons were used to determine where the differences existed. Similarly, comparisons between HBDL and SBDL in average power, peak power, average velocity, and peak velocity across the eight loads were conducted using paired t-tests. Partial eta squared (η_p^2) was used to measure effect sizes with values of <0.06, ≥0.06–0.13, and ≥0.14 considered small, medium, and large [4]. Furthermore, Hedges' *g* effect size (*g*) was calculated to assess the magnitude of the difference between SBDL and HBDL, and was interpreted as trivial (<0.2), small (0.2–0.6), moderate (>0.6–1.2), or large (>1.2–2.0) [8]. Percentage (%) difference was calculated using Microsoft Excel with the equation: $((mean_1 - mean_2)/\text{average of } mean_1 \text{ and } mean_2)*100$.

Table 2. Intraclass correlation coefficients for Peak Power, Average Power, Peak Velocity, and Average Velocity for hexagonal bar and straight bar deadlifts across loads

	Load (%1RM)							
	20%	30%	40%	50%	60%	70%	80%	90%
	Hexagonal Bar							
Peak power [Watts]	0.939	0.868	0.938	0.973	0.939	0.926	0.923	0.919
Average power [Watts]	0.921	0.971	0.993	0.976	0.969	0.957	0.944	0.863
Peak velocity [m/s]	0.926	0.924	0.956	0.802	0.897	0.840	0.943	0.903
Average velocity [m/s]	0.848	0.934	0.982	0.937	0.947	0.902	0.906	0.827
	Straight bar							
Peak power [Watts]	0.824	0.883	0.891	0.940	0.941	0.946	0.909	0.948
Average power [Watts]	0.922	0.970	0.982	0.976	0.960	0.983	0.972	0.969
Peak velocity [m/s]	0.856	0.925	0.890	0.876	0.823	0.804	0.922	0.942
Average velocity [m/s]	0.857	0.931	0.952	0.918	0.894	0.948	0.924	0.946

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, version 20, IBM Corp, Armonk, New York). The level of significance for all tests was set at $p < 0.05$.

Results

Intra-trial reliability for all dependent variables at each load and each bar were high. The ICC for the HBDL and SBDL across loads are presented in Table 2. Mean ± SD and 95% confidence intervals for peak power, average power, peak velocity, and average velocity across loads for the HBDL and SBDL are presented in Table 3. Furthermore, effect sizes (g) with magnitude are shown in Table 4.

The 1RM obtained was significantly higher for HBDL (121.1 ± 20.3) than SBDL (108.1 ± 17.8) ($p < 0.001$, g = 0.66, % difference = 11.3).

Peak power

Regarding peak power, results from the repeated measures ANOVA revealed a significant effect of load for HBDL ($p < 0.001$, $\eta_p^2 = 0.596$) and SBDL ($p < 0.001$, $\eta_p^2 = 0.643$). The mean ± standard error of peak power across loads for the HBDL and SBDL is presented in Figure 1. The peak power was observed at 80% 1RM (1053 W) for the HBDL and 90% 1RM (848 W) for the SBDL. A further post-hoc test revealed no significant differences between peak power obtained at 80% 1RM (i.e., highest peak power observed) and 50, 60, 70, and 90% 1RM for the HBDL. Similarly, the post-hoc test revealed no significant differences between 90% 1RM (i.e., the highest peak power observed) and 40–80% 1RM for the SBDL. A paired t-test indicated that peak power was significantly higher in the HBDL compared to the SBDL at 60% ($p = 0.028$, g = 0.53, % difference = 16.2) of 1RM.

Average power

For average power, results from the repeated measures ANOVA revealed a significant effect of load for both HBDL ($p < 0.001$, $\eta_p^2 = 0.778$) and SBDL ($p < 0.001$, $\eta_p^2 = 0.832$). In addition, the paired sample t-test indicated that average power was significantly higher in the HBDL compared to the SBDL at 50% ($p = 0.001$, g = 0.74, % difference = 18.5), 60% ($p = 0.005$. g = 0.56, % difference = 14.9), and 70% ($p = 0.012$, g = 0.60, % difference = 17.2) of 1RM. The mean ± standard error of average power across loads for the HBDL and SBDL is presented in Figure 2.

Peak velocity

For peak velocity, the repeated measures ANOVA revealed a significant effect of load for both HBDL ($p < 0.001$, $\eta_p^2 = 0.677$) and SBDL ($p < 0.001$, $\eta_p^2 = 0.675$). The mean ± standard error of peak velocity across loads for the HBDL and SBDL is presented in Figure 3. In addition, paired t-test revealed significantly greater peak velocity

Table 3. Mean ± SD and 95% Confidence Intervals for Peak Power, Average Power, Peak Velocity, and Average Velocity for the hexagonal bar and straight bar deadlifts across loads

	Load (%1RM)															
	20%		30%		40%		50%		60%		70%		80%		90%	
	M (SD)	95%CI	M (SD)	95%CI	M (SD)	95%CI	M (SD)	95%CI	M (SD)	95%CI	M (SD)	95%CI	M (SD)	95%CI	M (SD)	95%CI
Hexagonal Bar																
Peak power [Watts]	446.2 (138.1)	369.7–522.7	591.8 (175.3)	494.6–688.9	655.4 (197.5)	545.9–764.7	833.2 (287.4)	674.1–992.4	910.1* (298.7)	744.6–1075.5	1004 (443.8)	818.1–1279.8	1011.8 (425.0)	841.5–1263.3	873.9 (287.2)	714.3–1032.4
Average power [Watts]	198.1 (47.6)	171.6–221.4	270.4 (54.3)	240.3–300.5	323.6 (74.7)	282.2–365.1	404.1* (99.3)	348.9–459.1	446.4* (116.9)	381.1–511.2	492.6* (151.8)	408.5–576.6	503.6 (171.4)	408.6–598.5	463.7 (138.6)	387.1–540.5
Peak velocity [m/s]	1.25 (0.21)	1.13–1.37	1.21 (0.19)	1.11–1.32	1.12 (0.19)	1.01–1.23	1.10 (0.19)	1.00–1.21	1.03 (0.22)	0.91–1.15	0.97 (0.25)	0.83–1.11	0.89 (0.25)	0.75–1.03	0.77 (0.19)	0.66–0.88
Average velocity [m/s]	0.81 (0.15)	0.72–0.89	0.76 (0.12)	0.70–0.83	0.71 (0.13)	0.64–0.79	0.70* (0.10)	0.64–0.76	0.64 (0.13)	0.57–0.71	0.59 (0.13)	0.52–0.67	0.54 (0.14)	0.45–0.62	0.45 (0.11)	0.39–0.51
Straight Bar																
Peak power [Watts]	461.3 (141.3)	383.1–539.6	584.6 (204.5)	471.3–697.9	648.2 (232.1)	519.7–776.7	734.8 (204.3)	621.6–848.0	774.1 (184.3)	671.9–876.2	860.2 (229.5)	724.1–932.6	860.0 (209.2)	733.5–913.6	848.3 (185.7)	745.4–951.2
Average power [Watts]	183.2 (41.4)	160.2–206.2	248.5 (68.8)	210.3–286.6	292.2 (87.6)	244.1–340.5	335.8 (79.5)	291.7–379.8	384.6 (98.3)	330.2–439.1	414.7 (94.6)	362.3–467.1	447.2 (104.6)	389.3–505.2	468.9 (112.9)	406.3–531.5
Peak velocity [m/s]	1.36** (0.20)	1.25–1.47	1.22 (0.17)	1.12–1.32	1.13 (0.23)	1.00–1.26	1.11 (0.18)	1.1–1.21	1.03 (0.18)	0.93–1.14	0.96 (0.17)	0.86–1.05	0.87 (0.15)	0.79–0.96	0.82 (0.18)	0.72–0.93
Average velocity [m/s]	0.83 (0.16)	0.74–0.92	0.75 (0.16)	0.66–0.84	0.69 (0.17)	0.60–0.79	0.64 (0.12)	0.57–0.71	0.61 (0.10)	0.55–0.66	0.57 (0.10)	0.52–0.63	0.53 (0.10)	0.47–0.59	0.50** (0.11)	0.44–0.56

Note: *significantly greater at corresponding load compared to straight bar deadlift; ** significantly greater at corresponding load compared to hex bar deadlift.

Table 4. Hedge's g effect size for Peak Power, Average Power, Peak Velocity, and Average Velocity between the hexagonal bar and straight bar deadlifts across loads

	Load (%1RM)							
	20%	30%	40%	50%	60%	70%	80%	90%
Peak Power [Watts]	0.11 Trivial	0.04 Trivial	0.03 Trivial	0.38 Small	0.53 Small	0.40 Small	0.44 Small	0.10 Trivial
Average Power [Watts]	0.32 Small	0.34 Small	0.38 Small	0.74 Moderate	0.56 Small	0.60 Small	0.39 Small	0.04 Trivial
Peak Velocity [m/s]	–0.52 Small	–0.05 Trivial	0.05 Trivial	0.05 Trivial	0.00 Trivial	0.05 Trivial	0.09 Trivial	0.26 Small
Average Velocity [m/s]	–0.13 Trivial	0.07 Trivial	0.13 Trivial	0.53 Small	0.25 Small	0.17 Trivial	0.08 Trivial	0.44 Small

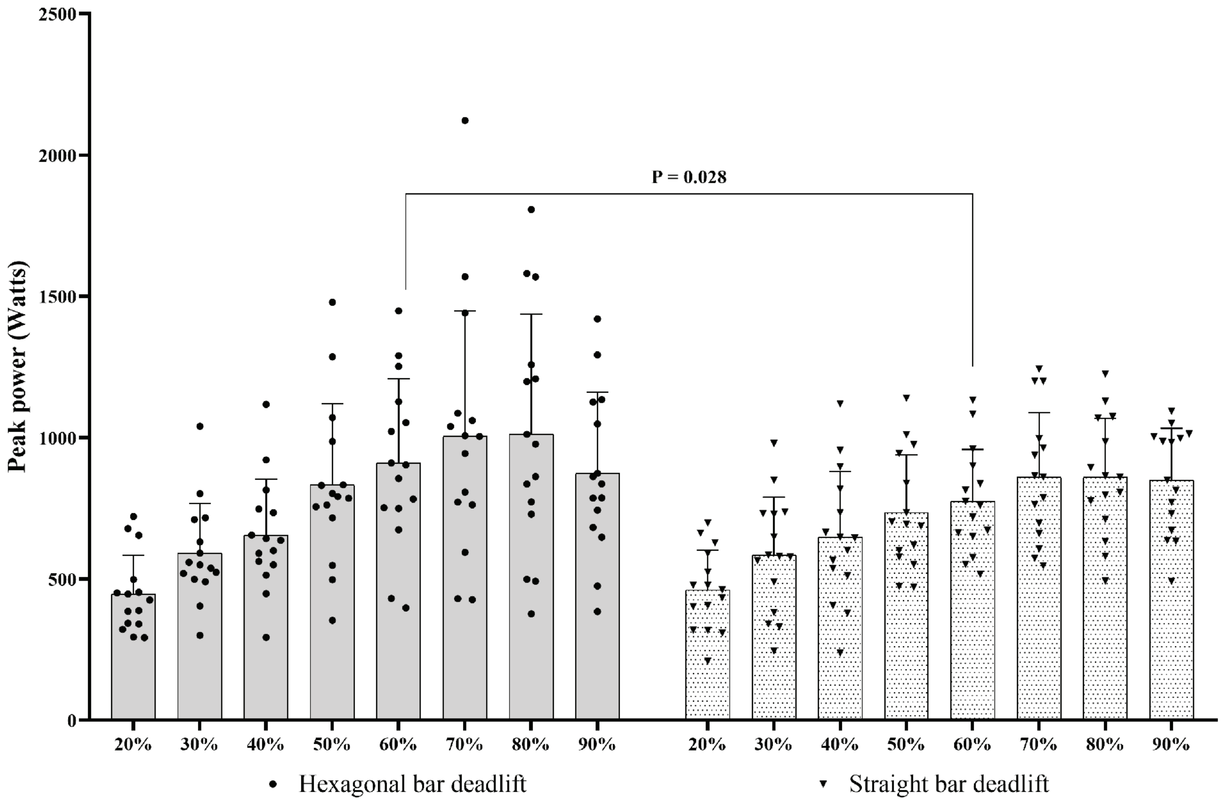

Figure 1. Mean (bars) and standard deviation (error bars) of peak power (Watts) during deadlift exercises at 20–90% 1RM using the hexagonal bar (grey bars) and straight bar (white dotted bars)

Note: Dotted circles (hexagonal bar) and inverted triangles (straight bar) represent each participant's individual data points.

for SBDL at 20% 1RM compared to HBDL ($p = 0.018$, $g = 0.52$, % difference = 8.4).

Average velocity

For average velocity, the repeated measures ANOVA revealed a significant effect of load for both HBDL ($p < 0.001$, $\eta_p^2 = 0.743$) and SBDL ($p < 0.001$, $\eta_p^2 = 0.614$). The mean ± standard error of average velocity across loads for the HBDL and SBDL is presented in Figure 3. In addition, paired t-test revealed significantly greater average velocity for HBDL at 50% 1RM ($p = 0.042$, $g = 0.53$, % difference = 9.0) and for SBDL at 90% 1RM ($p = 0.014$, $g = 0.44$, % difference = 10.5).

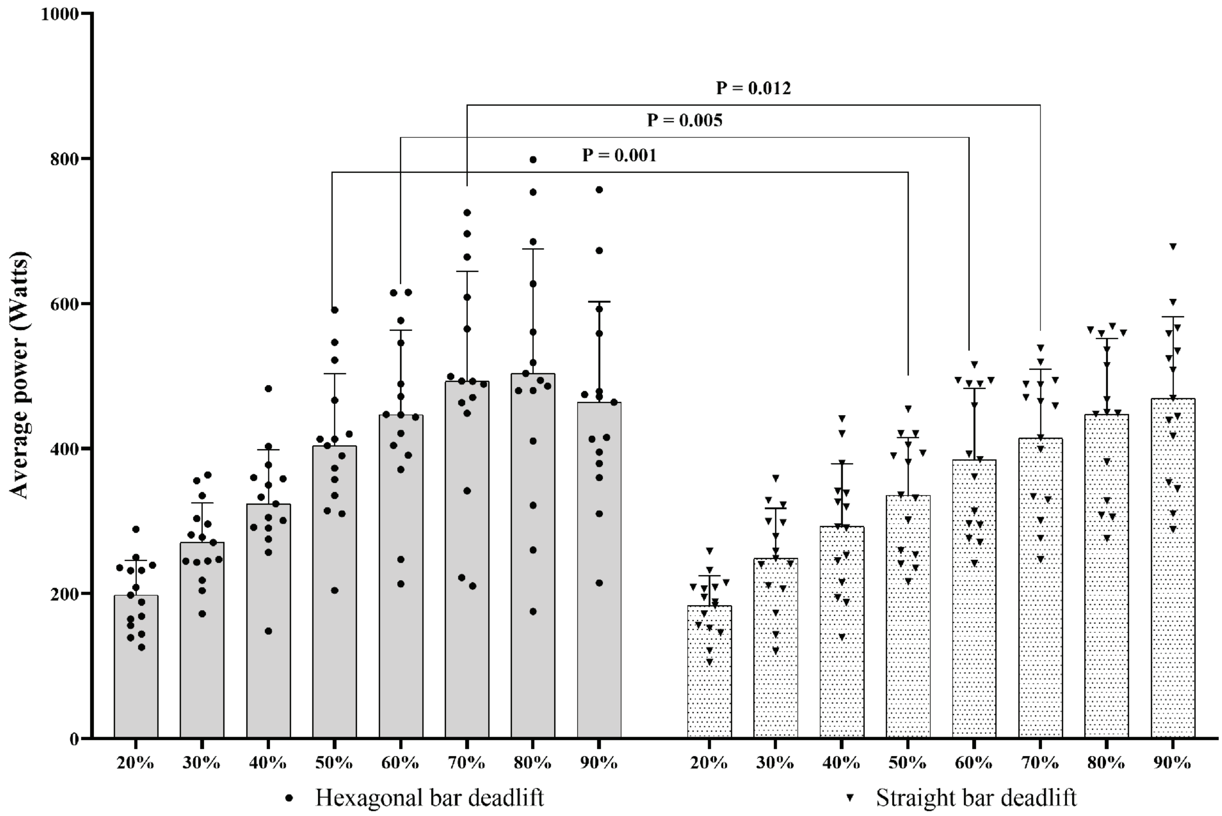

Figure 2. Mean (bars) and standard deviation (error bars) of average power (Watts) during deadlift exercises at 20-90% 1RM using the hexagonal bar (grey bars) and straight bar (white dotted bars).

Note: Dotted circles (hexagonal bar) and inverted triangles (straight bar) represent each participant's individual data points.

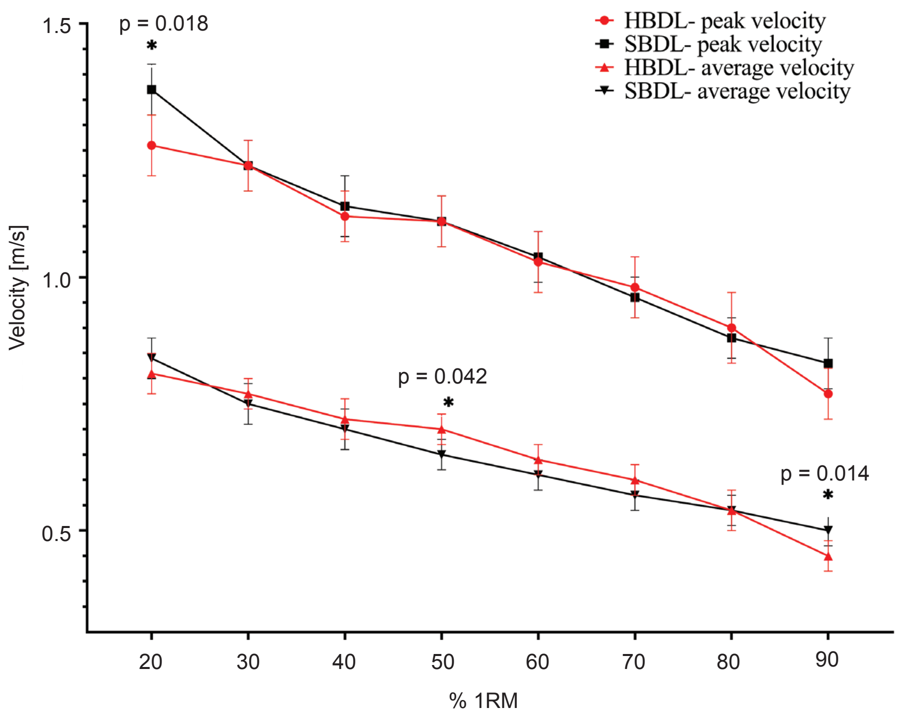

Figure 3. Mean ± standard error of peak velocity (m/s) and average velocity (m/s) during deadlift exercises at 20-90% 1RM using the straight and hexagonal bars

Note: * – denotes significant difference.

Discussion

The study aimed to 1) determine the OPL in the HBDL and SBDL exercises in non-specifically trained athletes and 2) compare differences in velocity and power outputs (i.e., peak and average) between the HBDL and SBDL. Our results suggest no one load where peak power is optimized during the HBDL or SBDL. However, peak power outputs for the HBDL are similar across 50–90% 1RM, with the highest peak power observed at 80% 1RM (1053 W). Similarly, the peak power output for the SBDL is similar across 40–90% 1RM, with the highest peak power observed at 90% 1RM (843 W). When the HBDL and SBDL were compared across a range of loads, power output at 60% 1RM was greater in HBDL. Likewise, the average power output at 50%-70% and average velocity at 50% 1RM was greater in HBDL. However, the peak velocity at 20% and average velocity at 90% 1RM was greater in SBDL.

Our findings reported that peak power can be obtained across 50–90% 1RM in the HBDL and 40–90% 1RM in the SBDL. Swinton et al. [21] reported peak power output to occur at 40% 1RM for the HBDL. However, the author's [21] did not report any data to distinguish whether significant differences were present between the observed peak power (i.e., 40% 1RM) and corresponding loads at 30–50% 1RM, making it difficult to compare with our findings directly. Furthermore, the author's [21] also reported peak power at 30% 1RM for the SBDL, which contrasts with the results from the study by Blatnik et al. [2], whereby this occurred at 50% 1RM. Similarly, for the HBDL, Swinton et al. [21] reported the highest peak power outputs to occur at 30% 1RM but again did not report any data to distinguish whether significant differences were present between the observed peak power (i.e., 30% 1RM) and corresponding loads of 20–40% 1RM, which again makes it difficult to compare our findings. Similarly, Blatnik et al. [2] also reported the observed peak power (i.e., 50% 1RM), but the authors reported that peak power at 50% 1RM was not significantly different from 40, 60, and 70% 1RM. Therefore, peak power can be obtained across 40–70% 1RM for the SBDL. This concurs with our findings which indicate that the OPL in this exercise occurs within the range of 40–90% 1RM.

Further discrepancies from prior research were observed regarding power output. For example, Swinton et al. [21] reported peak power was 4872 W for the HBDL and 4388 W for the SBDL, which contrasted with the peak power of 1462 W for the SBDL reported by Blatnik et al. [2]. The reason for these contradictory findings is the different data collection procedures used. Swinton et al. [21] used a force platform to measure the peak power output, which calculates peak power output considering bar mass as well as the body mass of the individual. However, Blatnik et al. [2] used a force platform and considered participants' body mass to determine peak power output; the authors also calculated bar-power through video motion analysis. Indeed, Blatnik et al. [2] reported peak power obtained was significantly different between the barbell, body, and system. For example, peak power occurred at 50% 1RM for the barbell, 30% 1RM for the body, and 70% 1RM for the system. These discrepancies in the literature for the OPL in the deadlift exercise further make it difficult to compare our findings. However, when only bar-power was considered during SBDL, Blatnik et al. [2] reported it to be 1358–1462 W across 40–70% 1RM, whereas our findings suggest it to be 648–848 W across 40–90% 1RM. These disparities may be due to the different strength and experience levels of participants recruited in these studies. Blatnik et al. [2] reported the average 1RM of the participants to be 203 kgs compared to 107 kgs in the present study.

Another finding from our study suggests HBDL is superior in producing peak power and average power outputs compared to SBDL across different loads, which aligns with prior research [3, 12, 21]. Swinton et al. [21] reported greater peak power outputs in the HBDL compared to the SBDL across 30–80% 1RM among male powerlifters with >14 years of resistance training experience. Similarly, Camara et al. [3] found significantly greater peak power values across 65–85% 1RM in moderately resistance trained (>3 days per week) individuals. Furthermore, reported greater average power output for the HBDL compared to SBDL at 90% 1RM in healthy participants with experience in both lifting techniques. These findings may be attributed to structural differences in the barbell types (i.e., hexagonal bar vs. straight bar) that might have led to biomechanical differences while performing the deadlift. For example, Swinton et al. [21] reported reduced horizontal displacement away from the body using HBDL by ~75% compared to the SBDL. Indeed, with increased load (i.e., more than 60% 1RM), the HBDL increased displacement towards the body by ~22%. These biomechanical differences during lifting are advantageous to the HBDL, as the load is closer to the body's center of gravity, allowing higher loads to be lifted at faster velocities, thus resulting in increased power production. Furthermore, Camara et al. [3] also compared the muscle activation of the biceps femoris, erector spinae, and vastus lateralis between the HBDL and SBDL. They observed greater normalized EMG values for the vastus lateralis during concentric and eccentric actions in the HBDL compared to the SBDL. This suggests greater quadriceps involvement during the HBDL and greater posterior chain involvement during the SBDL. This may somewhat explain the higher power production in the HBDL exercise as a direct consequence of greater vertical force production. In the present study, the hex bar used had elevated handles as opposed to handles in line with the center of the weight disc. Prior literature rarely reports handle position when using hex bars. Still, it is possible that an elevated handle position reduced the range of motion, which might influence mechanical parameters produced when using a hex bar. Future research examining this possibility would be worthy of pursuit.

Finally, Lake et al. [12] reported significantly faster average velocities with the HBDL compared to the SBDL exercise at 90% 1RM. In contrast, we observed faster average velocities with SBDL at 90% 1RM. However, at 50% 1RM, we observed faster average velocities with HBDL. These contradictory findings at 90% 1RM may be due to the testing nature used in both studies. For example, Lake et al. [12] compared the HBDL and SBDL at only one load (i.e., 90% 1RM). However, our study compared the same across different incremental loads (i.e., 20–90% 1RM). Another possible reason may be the instructions given to participants during both studies. In our study, the participants were asked to lift the weight as fast as possible, whereas in the study by Lake et al. [12] no such instructions were reported. Additionally, very few studies have reported velocity variables between the HBDL and SBDL, making it difficult to compare with the current study. Nevertheless, the agreement between the aforementioned data in both studies (e.g., average power output) suggests that the HBDL should be prioritized over the SBDL when implementing power-oriented training programs.

Limitations

The following limitations should be acknowledged for this study. Firstly, data reliability is based on the methods chosen (i.e., a non-incremental exercise protocol). Whereas prior research suggests using incremental loads and considering body mass, which is important for athletes that need to produce high levels of power against their body mass (e.g., in soccer, basketball, and rugby union) [13]. Secondly, the present study employed a minimum training age of two years as an inclusion criterion. This was to ensure participants were technically proficient in the deadlift. However, the participants in the current study, although engaging in regular strength training, were not specialist strength athletes (e.g., weightlifters or powerlifters). Therefore, the study findings should only be considered for novice athletes of similar 1RM levels reported in our study. Future research is warranted to define the OPL for the deadlift exercise across different strength levels. Thirdly, limited research has reported velocity variables, making direct comparison with our findings difficult. Therefore, future studies are advised to include these variables.

Practical applications

Our study revealed no specific load where the OPL in the deadlift exercise occurs for novice strength-trained athletes. For both HBDL and SBDL, the OPL may occur across a range of loads. Specifically, the OPL for HBDL lies between 50-90% 1RM, with the highest peak power observed at 80% 1RM. Similarly, the OPL for SBDL lies across 40-90% 1RM, with the highest peak power observed at 90% 1RM. Therefore, practitioners and athletes are advised to use the ranges of loads reported in this study to determine the 'optimum power zone' [13] in these respective deadlift exercises. Additionally, we observed greater peak power and average power output in HBDL compared to SBDL in their respective %RM loads. Thus, the HBDL may offer additional advantages for power development in terms of movement velocity and power production (when compared to the SBDL), which may have important implications for training and testing purposes.

Conclusions

The results from this study conclude that the OPL in the HBDL exercise may occur across 50–90% 1RM, with the highest peak power being observed at 80% 1RM (1053 W). For the SBDL exercise, the OPL occurs across 40–90% 1RM, with the highest peak power observed at 90% 1RM (843 W). In addition, when HBDL and SBDL were compared across loads, HBDL was superior in generating peak power output at 60% 1RM and average power output at 50–70% 1RM. Future research may compare the longitudinal effects of HBDL and SBDL in inducing neuromuscular adaptions across athletes participating in different sports.

Conflict of interest: Authors state no conflict of interest.

References

1. Benavides-Ubric A., Díez-Fernández D.M., Rodríguez-Pérez M.A., Ortega-Becerra M., Pareja-Blanco F. (2020) Analysis of the load-velocity relationship in deadlift exercise. *J. Sports Sci. Med.,* 19: 452-459.
2. Blatnik J.A., Goodman C.L., Capps C.R., Awelewa O.O., Triplett T.N., Erickson T.M., McBride J.M. (2014) Effect of load on peak power of the bar, body and system during the deadlift. *J. Sports Sci. Med.,* 13: 511-515.
3. Camara K.D., Coburn J.W., Dunnick D.D., Brown L.E., Galpin A.J., Costa P.B. (2016) An examination of muscle activation and power characteristics while performing the deadlift exercise with straight and hexagonal barbells. *J. Strength Cond. Res.,* 30: 1183-1188. DOI: 10.1519/jsc.0000000000001352.
4. Cohen J. (1988) *Statistical Power Analysis for the Behavioral Sciences.* Second ed. Hillsdale: Lawrence Erlbaum Associates.

5. Cormie P., McCaulley G.O., Triplett N.T., McBride J.M. (2007) Optimal loading for maximal power output during lower-body resistance exercises. *Med. Sci. Sports Exerc.,* 39: 340-349. DOI: 10.1249/01.mss.0000246993.71599.bf.
6. Cormie P., McGuigan M.R., Newton R.U. (2011) Developing maximal neuromuscular power: Part 2 – training considerations for improving maximal power production. *Sports Med.,* 41: 125-146. DOI: 10.2165/11538500-000000000-00000.
7. Garnacho-Castaño M.V., López-Lastra S., Maté-Muñoz J.L. (2015) Reliability and validity assessment of a linear position transducer. *J. Sports Sci. Med.,* 14: 128-136.
8. Hopkins W.G., Marshall S.W., Batterham A.M., Hanin J. (2009) Progressive statistics for studies in sports medicine and exercise science. *Med. Sci. Sports Exerc.,* 41: 3-13. DOI: 10.1249/MSS.0b013e31818cb278.
9. Jennings C.L., Viljoen W., Durandt J., Lambert M.I. (2005) The reliability of the fitrodyne as a measure of muscle power. *J. Strength Cond. Res.,* 19: 859-863. DOI: 10.1519/r-15984.1.
10. Koo T.K., Li M.Y. (2016) A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J. Chiropr. Med.,* 15: 155-163. DOI: 10.1016/j.jcm.2016.02.012.
11. Kraemer W.J., Ratamess N., Fry A.C., French D. (2006) Strength training: Development and evaluation of methodology. In: Maud P.J. and Foster C., (eds). Physiological assessment of human fitness. Human Kinetics, Second ed. Champaign, IL, pp. 119-150.
12. Lake J., Duncan F., Jackson M., Naworynsky D. (2017) Effect of a hexagonal barbell on the mechanical demand of deadlift performance. *Sports* (Basel), 5. DOI: 10.3390/sports5040082.
13. Loturco I., Dello Iacono A., Nakamura F.Y., Freitas T.T., Boullosa D., Valenzuela P.L., Pereira L.A., McGuigan M.R. (2021) The optimum power load: A simple and powerful tool for testing and training. *Int. J. Sports Physiol. Perform.,* 17: 151-159. DOI: 10.1123/ijspp.2021-0288.
14. Loturco I., McGuigan M.R., Freitas T.T., Valenzuela P.L., Pereira L.A., Pareja-Blanco F. (2021) Performance and reference data in the jump squat at different relative loads in elite sprinters, rugby players, and soccer players. *Biol. Sport,* 38: 219-227. DOI: 10.5114/biolsport.2020.98452.
15. Loturco I., Nakamura F.Y., Tricoli V., Kobal R., Cal Abad C.C., Kitamura K., Ugrinowitsch C., Gil S., et al. (2015) Determining the optimum power load in jump squat using the mean propulsive velocity. *PLoS One,* 10: e0140102. DOI: 10.1371/journal.pone.0140102.
16. Loturco I., Suchomel T., Bishop C., Kobal R., Pereira L.A., McGuigan M. (2019) 1rm measures or maximum bar-power output: Which is more related to sport performance? *Int. J. Sports Physiol. Perform.,* 14: 33-37. DOI: 10.1123/ijspp.2018-0255.
17. Loturco I., Suchomel T., James L.P., Bishop C., Abad C.C.C., Pereira L.A., McGuigan M.R. (2018) Selective influences of maximum dynamic strength and bar-power output on team sports performance: A comprehensive study of four different disciplines. *Front. Physiol.,* 9: 1820. DOI: 10.3389/fphys.2018.01820.
18. Nigro F., Bartolomei S. (2020) A comparison between the squat and the deadlift for lower body strength and power training. *J. Hum. Kinet.,* 73: 145-152. DOI: 10.2478/hukin-2019-0139.
19. Soriano M.A., Jiménez-Reyes P., Rhea M.R., Marín P.J. (2015) The optimal load for maximal power production during lower-body resistance exercises: A meta-analysis. *Sports Med.,* 45: 1191-1205. DOI: 10.1007/s40279-015-0341-8.
20. Suchomel T.J., Nimphius S., Stone M.H. (2016) The importance of muscular strength in athletic performance. *Sports Med.,* 46: 1419-1449. DOI: 10.1007/s40279-016-0486-0.
21. Swinton P.A., Stewart A., Agouris I., Keogh J.W., Lloyd R. (2011) A biomechanical analysis of straight and hexagonal barbell deadlifts using submaximal loads. *J. Strength Cond. Res.,* 25: 2000-2009. DOI: 10.1519/JSC.0b013e3181e73f87.
22. Valenzuela P.L., McGuigan M., Sánchez-Martínez G., Torrontegi E., Vázquez-Carrión J., Montalvo Z., Abad C.C.C., Pereira L.A., et al. (2020) Reference power values for the jump squat exercise in elite athletes: A multicenter study. *J. Sports Sci.,* 38: 2273-2278. DOI: 10.1080/02640414.2020.1783150.
23. Weakley J., Mann B., Banyard H., McLaren S., Scott T., Garcia-Ramos A. (2021) Velocity-based training: From theory to application. *Strength Cond. J.,* 43: 31-49. DOI: 10.1519/SSC.0000000000000560.
24. Weldon A., Duncan M.J., Turner A., Lockie R.G., Loturco I. (2021) Practices of strength and conditioning coaches in professional sports: A systematic review. *Biol. Sport,* 39: 715-726. DOI: 10.5114/biolsport.2022.107480.
25. Weldon A., Duncan M.J., Turner A., Sampaio J., Noon M., Wong D., Lai V.W. (2021) Contemporary practices of strength and conditioning coaches in professional soccer. *Biol. Sport,* 38: 377-390. DOI: 10.5114/biolsport.2021.99328.

Received 20.06.2023
Accepted 21.08.2023