Effect of Various Loads on the Force-Time Characteristics of the Hang High Pull

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Abstract

Suchomel, TJ, Beckham, GK, and Wright, GA. Effect of various loads on the force-time characteristics of the hang high pull. *J Strength Cond Res* 29(5): 1295–1301, 2015—The purpose of this study was to investigate the effect of various loads on the force-time characteristics associated with peak power during the hang high pull (HHP). Fourteen athletic men (age: 21.6 ± 1.3 years; height: 179.3 ± 5.6 cm; body mass: 81.5 ± 8.7 kg; 1 repetition maximum [1RM] hang power clean [HPC]: 104.9 ± 15.1 kg) performed sets of the HHP at 30, 45, 65, and 80% of their 1RM HPC. Peak force, peak velocity, peak power, force at peak power, and velocity at peak power were compared between loads. Statistical differences in peak force ($p = 0.001$), peak velocity ($p < 0.001$), peak power ($p = 0.015$), force at peak power ($p < 0.001$), and velocity at peak power ($p < 0.001$) existed, with the greatest values for each variable occurring at 80, 30, 45, 80, and 30% 1RM HPC, respectively. Effect sizes between loads indicated that larger differences in velocity at peak power existed as compared with those displayed by force at peak power. It seems that differences in velocity may contribute to a greater extent to differences in peak power production as compared with force during the HHP. Further investigation of both force and velocity at peak power during weightlifting variations is necessary to provide insight on the contributing factors of power production. Specific load ranges should be prescribed to optimally train the variables associated with power development during the HHP.

Key Words power training, weightlifting derivatives, lower-body power, optimal load

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Introduction

The hang high pull (HHP) is a weightlifting variation that can also be used as a teaching progression for the power clean (11,16,28). Previous research also indicates that the HHP alone may also be used to improve lower-body muscular power by training the triple extension movement (31,33), which seems to be why power clean variations are often prescribed in resistance training (15). Thomas et al. (33) examined differences between a barbell HHP and a fixed form (Smith machine) HHP across a loading spectrum that ranged from 30 to 70% 1 repetition maximum (1RM) HHP. Their results indicated that there was no statistical difference regarding the form of HHP and that peak power was not statistically different between 30 and 60% 1RM HHP. A previous study by Suchomel et al. (31) compared the peak force, peak velocity, and peak power between the HHP and hang power clean (HPC) performed at the same absolute loads. Their study indicated that the HHP produced statistically greater peak velocity and peak power as compared with the HPC. Furthermore, it was suggested that the greatest peak force, peak velocity, and peak power during the HHP occurred at 80, 30, and 45% of their subject's 1RM HPC, respectively. However, only main effect differences were discussed. Similarly, Thomas et al. (33) only analyzed peak power and normalized peak power between loads ranging 30–70% 1RM HHP.

A potential benefit to prescribing weightlifting derivatives, such as the HHP, is the elimination of the catch phase. Previous research has indicated that although training with weightlifting movements typically results in a low injury rate, chronic use of weightlifting movements that involve the catch phase may increase overuse injuries to the wrists and shoulders of athletes (24). To decrease the potential risk of injury to the wrist and shoulders, Suchomel and Sato (29) suggested using weightlifting movements without the catch phase (e.g., HHP, jump shrug, and midthigh pull). Further research has suggested that it may be beneficial to implement derivative exercises to enhance explosive strength during the second pull movement in less skillful athletes (9). It has also been suggested that practitioners should prescribe exercises that allow them to accelerate through the entire movement (15,23). Exercises of this nature may be advantageous because they may allow for greater muscle activation throughout the movement (23) and also mimic the movement profiles of almost all rapid movements in sports to a greater extent than exercises with a deceleration phase (15). By prescribing weightlifting derivatives that eliminate the catch phase and emphasize the completion of the explosive triple extension movement, the training stimulus will more likely mimic sport-specific movement patterns and may allow for greater kinetic and kinematic magnitudes (1,2,30–32) as compared with weightlifting movements that include the catch phase. Furthermore, prescribing derivatives such as the HHP and jump shrug will allow athletes to overload the stretch-shortening cycle that is characteristic of many movements in sports (e.g., jumping, sprinting, and change of direction).

Because the power clean and its variations are often prescribed in resistance training programs (3,6,15,17,18), it seems that it may be more informative to provide practitioners with information about other aspects of each exercise variation. Currently, it seems that there is a lack of information that exists regarding how the external load impacts the magnitude of lower-body force-time characteristics that contribute to peak power production during the HHP. With this information, strength and conditioning practitioners may be able to make more informed decisions about the proper loading schemes needed to meet the training goals of their athletes. Therefore, the purpose of this study is to examine the effect of various loads on the force-time characteristics associated with peak power during the HHP. Based on previous research (30,31), it is hypothesized that peak force, peak velocity, and peak power will occur at 80, 30, and 45% 1RM HPC, respectively, and that each lower-body performance variable will display statistical differences between loads.

METHODS

Experimental Approach to the Problem

This study used a repeated-measures design to test our hypotheses and determine the effect of load on lower-body force-time characteristics during the HHP. Each subject completed a familiarization session followed 2–7 days later by a single testing session. The purpose of the familiarization session was to determine the 1RM HPC of each subject and familiarize the subjects with the HHP exercise. The testing session required each subject to complete 3 single repetitions each of the HHP at relative loads of 30, 45, 65, and 80% of their 1RM HPC on a force platform in random order. Peak force, peak velocity, peak power, force at peak power, and velocity at peak power were compared between loads using a series of 1-way repeated-measures analysis of variance.

Subjects

Fourteen athletic males (mean ± *SD*; age: 21.6 ± 1.3 years; height: 179.3 ± 5.6 cm; body mass: 81.5 ± 8.7 kg; 1RM HPC 104.9 ± 15.1 kg) with at least 2 years of previous training experience with the HPC volunteered to participate in this investigation. Each of the subjects participated in NCAA Division III collegiate track and field (short sprints, jumps, or throws) or collegiate club/intramural sports. The subjects ranged in age from 19–23 years old. None of the subjects had any competitive weightlifting experience. This study was approved by the University of Wisconsin–La Crosse Institutional Review Board. Additional approval was obtained from the Institutional Review Board of East Tennessee State University. All subjects were informed of the possible risks of involvement in the study and provided written informed consent. Subjects were asked to refrain from physical activity that may have affected testing performance, including the consumption of alcohol, caffeine, and other ergogenic aids at least 24 hours before each testing session. If subjects did not meet these standards on their arrival, they were asked to reschedule their testing session.

Procedures

Before activity, every subject completed the same standardized dynamic warm-up, which consisted of 3 minutes of light cycling and the following dynamic stretches that each covered 10 m: walking forward lunge, walking backward lunge, lateral lunges in both directions, walking hamstring stretch, and walking quadriceps stretch. The subjects then completed 5 slow body weight squats, 5 fast body weight squats, and 5 countermovement jumps of increasing intensity. This was then followed by submaximal HPC sets at approximately 30, 50, 70, and 90% of each subject's estimated 1RM HPC in accordance with previous research (26,27,31,34). Furthermore, an HPC 1RM was completed because it may be impractical to complete a 1RM test for the HHP in an athletic setting. Subjects lifted progressively higher loads until missing a single load twice; the highest completed attempt was recorded as their 1RM. A minimum 2.5-kg increase in load was used between 1RM repetitions. Each HPC repetition was performed using technique previously described by Suchomel et al. (27). Briefly, the subjects started the HPC by holding the bar in a standing position, with their knees slightly bent, and the bar at the midthigh position. The subjects then performed a countermovement by flexing at the hip, while maintaining their knee angle, and lowering the bar to a position just above their knee. After reaching this position, the subjects immediately changed direction to transition back to the midthigh position by flexing their knees and moving their torso to an upright position. On reaching the midthigh position with the bar, the subjects immediately performed the second pull movement by rapidly extending their hips, knees, and ankles and by shrugging their shoulders. The bar was lifted up with maximum effort and was caught across the subject's shoulders in a semisquat position. Any HPC repetition caught in a squat position where the upper thigh of the subject was below parallel to the floor was determined to be unsuccessful.

After a 1RM was established, subjects performed light exercise sets with approximately 30% of their 1RM HPC to

Table 1. Intraclass correlation coefficient (ICC) ranges of each performance variable during the hang high pull ($n = 14$).*

Variable	ICC range
Force	0.97–0.99
Velocity	0.86–0.96
Power	0.95–0.98
Force at peak power	0.97–0.99
Velocity at peak power	0.85–0.95

*The ICC ranges represent the ICC values that occurred at each load for each variable.

become familiarized with the proper HHP technique. Similar to the HPC, the HHP required the subject to start in the midthigh position, flex at the hip and lower the bar to the knee, and immediately change direction to begin the transition phase into the second pull. After transitioning to the midthigh position, the subjects immediately began the second pull phase by rapidly extending their hips, knees, and ankles and shrugging their shoulders, driving their elbows upward, and elevating the barbell to chest height (11,16,28,31). For the countermovement for both the HPC and HHP, the subjects were instructed to lower the barbell to a position just above the knee and immediately transition back to the midthigh position in 1 fluid motion without pausing at the knee.

Each subject returned for a single testing session 2–7 days after their familiarization session. Before performing testing repetitions, every subject completed the same dynamic warm-up described above. This was then followed by submaximal exercise sets of the HHP at 30 and 50% of their 1RM HPC. After the warm-up exercise sets, subjects performed 3 maximal effort repetitions each of the HHP at relative loads of 30, 45, 65, and 80% of their 1RM HPC in a randomized order totaling 12 repetitions. Subjects completed 3 single repetitions at a given load, and then the load was changed. To prevent any potentiating or fatiguing effects, the external load order was randomized. Subjects were provided with 1 minute of recovery between repetitions (10) and 2 minutes of rest were provided between each load. Subjects placed the barbell on the safety bars of a squat rack, which were positioned just below hip height for each subject, to prevent fatigue in between repetitions. Subjects lifted the barbell off of the rack and stepped backward onto the force plate outside of the squat rack. The subjects were allowed to wear weightlifting shoes during all HPC and HHP repetitions but were not allowed to use weightlifting straps. Finally, all subjects were encouraged to perform all repetitions with maximal effort.

Data Analysis

Every HHP repetition was performed on a portable Kistler Quattro Jump force platform (Type 9290AD; Kistler, Winterthur, Switzerland) interfaced with a laptop computer. The sampling rate of the force platform was 500 Hz. The force platform methodology used in this study has been supported by previous research by Hori et al. (13,14). Vertical ground reaction forces of the lifter plus bar system were measured directly with the force platform, and the raw force-time data were exported into a template created in Microsoft Excel (Microsoft Corp., Redmond, WA, USA). Forward dynamics were used to calculate the velocity of the lifter plus bar system during each repetition (17). Peak values of force, velocity, and power were extracted from the concentric phase of the force-time, velocity-time, and power-time data, respectively. The onset of the concentric phase of the movement was determined from the velocity-time curve as the point in which the velocity of the lifter plus

Table 2. The effect of load on hang high pull performance variables (mean ± *SD*) ($n = 14$).*

Load (% 1RM HPC)	PF (N)	PV ($m \cdot s^{-1}$)	PP (W)	F_{PP} (N)	V_{PP} ($m \cdot s^{-1}$)
30	2920.9 ± 514.1	2.05 ± 0.25	4479.60 ± 1104.44	2583.2 ± 404.7	1.73 ± 0.22
45	3172.0 ± 686.0†	1.95 ± 0.18	4596.37 ± 976.45	2775.2 ± 423.4‡	1.67 ± 0.16
65	3193.7 ± 530.1§	1.78 ± 0.14§‖	4296.11 ± 865.22¶	2772.2 ± 417.9§	1.55 ± 0.13§¶
80	3254.0 ± 534.4‡	1.68 ± 0.14‡‖#	4190.28 ± 812.80¶	2877.6 ± 419.7‡¶#	1.48 ± 0.12‡‖#

*HPC = hang power clean; PF = peak force; PV = peak velocity; PP = peak power; FPP = force at peak power; VPP = velocity at peak power.
†Statistically different from value at 30% 1RM HPC ($p \leq 0.05$).
‡Statistically different from value at 30% 1RM HPC ($p < 0.001$).
§Statistically different from value at 30% 1RM HPC ($p < 0.01$).
‖Statistically different from value at 45% 1RM HPC ($p < 0.001$).
¶Statistically different from value at 45% 1RM HPC ($p < 0.04$).
#Statistically different from value at 65% 1RM HPC ($p \leq 0.05$).

bar system changed from negative to positive. The end of the concentric phase was classified as point in which the force of the lifter plus bar system reached zero or near zero after the highest magnitude of force during the concentric phase. Power of the lifter plus bar system was equal to the product of the force and velocity. Force and velocity at peak power values were the respective force and velocity that occurred at peak power. The greatest values of peak force, peak velocity, peak power, force at peak power, and velocity at peak power produced by the subjects at each load were used for comparison.

Statistical Analyses

A series of 1-way repeated-measures analysis of variance were used to compare the differences in the peak force, peak velocity, peak power, force at peak power, and velocity at peak power within the HHP exercise at the various loads examined (30, 45, 65, and 80% 1RM HPC). If the assumption of sphericity was violated, Greenhouse-Geisser adjusted values were reported. The Bonferroni technique was used for post hoc analyses when necessary. The alpha value was set at 0.05 for all statistical measures. Effect sizes for post hoc tests were calculated using Cohen's d and were interpreted using the scale developed by Hopkins (12), where effect sizes were considered trivial, small, moderate, large, very large, and nearly perfect when Cohen's d was 0.0, 0.2, 0.6, 1.2, 2.0, and 4.0, respectively. Statistical power ranged between 0.85 and 1.00 for all measures. Confidence intervals (CIs) for mean difference were calculated for all pairwise comparisons at a 95% confidence level. Finally, the intrasession reliability of the measured variables was determined by intraclass correlation coefficients between the 3 repetitions performed at each load and the values are displayed in Table 1. All statistical analyses were performed using SPSS 21 (IBM, New York, NY, USA).

Results

The peak force, peak velocity, peak power, force at peak power, and velocity at peak power data are displayed in Table 2. Statistically significant differences in peak force ($F_{(2.04,26.53)} = 9.799$, $p = 0.001$), peak velocity ($F_{(3,39)} = 42.973$, $p < 0.001$), peak power ($F_{(1.56,20.25)} = 5.833$, $p = 0.015$), force at peak power ($F_{(1.71,22.22)} = 31.728$, $p < 0.001$), and velocity at peak power ($F_{(3,39)} = 24.835$, $p < 0.001$) existed between the loads examined. The peak force at 30% 1RM HPC was statistically lower than the peak force at 45% ($p = 0.019$, $d = 0.41$, CI = 34.31–467.86), 65% ($p = 0.002$, $d = 0.52$, CI = 102.44–443.18), and 80% 1RM HPC ($p = 0.004$, $d = 0.64$, CI = 102.69–563.55); however, no other statistical differences existed between loads ($p > 0.05$). The peak velocity at 30% 1RM HPC was statistically greater than the peak velocity at 65% ($p < 0.001$, $d = 1.33$, CI = 0.13–0.39) and 80% 1RM HPC ($p < 0.001$, $d = 1.83$, CI = 0.23–0.51), but not statistically different than the peak velocity at 45% 1RM HPC ($p = 0.199$, $d = 0.46$, CI = −0.03 to 0.21). In addition, the peak velocity at 45% 1RM HPC was statistically greater than the peak velocity at 65% ($p < 0.001$, $d = 1.05$, CI = 0.08–0.26) and 80% 1RM HPC ($p < 0.001$, $d = 1.67$, CI = 0.18–0.38). Finally, the peak velocity at 65% 1RM HPC was statistically greater than the peak velocity at 80% 1RM HPC ($p = 0.001$, $d = 0.71$, CI = 0.04–0.17). The peak power at 45% 1RM HPC was statistically greater than the peak power at 65% ($p = 0.015$, $d = 0.33$, CI = 51.27–549.25) and 80% 1RM HPC ($p = 0.011$, $d = 0.45$, CI = 82.99–729.19), but not statistically greater than the peak power at 30% 1RM HPC ($p = 1.000$, $d = 0.11$, CI = −158.82 to 392.46). No other statistical differences in peak power existed between loads ($p > 0.05$). The force at peak power at 80% 1RM HPC was statistically greater than the force at peak power at 30% ($p < 0.001$, $d = 0.71$, CI = 165.32–423.45), 45% ($p = 0.038$, $d = 0.24$, CI = 4.54–200.10), and 65% 1RM HPC ($p = 0.001$, $d = 0.25$, CI = 43.34–167.31). In addition, the force at peak power at 30% 1RM HPC was statistically lower than the force at peak power at 45% ($p < 0.001$, $d = 0.46$, CI = 123.85–260.28) and 65% ($p = 0.001$, $d = 0.46$, CI = 78.32–299.81). No statistical difference in force at peak power existed between the values that occurred at 45 and 65% 1RM HPC ($p > 0.05$). The velocity at peak power at 30% 1RM HPC was statistically greater than the velocity at peak power at 65% ($p = 0.001$, $d = 1.00$, CI = 0.08–0.29) and 80% 1RM HPC ($p < 0.001$, $d = 1.41$, CI = 0.13–0.38) but was not statistically different than the velocity at peak power at 45% 1RM HPC ($p = 0.439$, $d = 0.31$, CI = −0.04 to 0.17). In addition, the velocity at peak power at 45% 1RM HPC was statistically greater than the velocity at peak power at 65% ($p = 0.007$, $d = 0.82$, CI = 0.03–0.21) and 80% 1RM HPC ($p < 0.001$, $d = 1.34$, CI = 0.09–0.29). Finally, the velocity at peak power at 65% 1RM HPC was statistically greater than the velocity at peak power at 80% 1RM HPC ($p = 0.047$, $d = 0.56$, CI = 0.00–0.14).

Discussion

The aim of this study was to investigate the effect of various loads on the force-time characteristics associated with peak power during the HHP exercise. The main findings of this study were that HHP peak force, peak velocity, and peak power occurred at 80, 30, and 45% 1RM HPC, respectively, and statistical differences existed in peak force, peak velocity, peak power, force at peak power, and velocity at peak power between the loads examined. Therefore, the findings of this study support our original hypotheses regarding the impact of load on lower-body force-time characteristics during the HHP.

This study displayed that the greatest peak force during the HHP occurred at 80% 1RM HPC. Peak force during the HHP increased as the external load increased, which is in line with previous research on other explosive exercise movements (17,23). The peak force produced by the subjects at 45, 65, and 80% 1RM HPC were not statistically different from each other, which indicates that the subjects produced similar magnitudes of force despite increasing loads. Thus, it seems that a similar stimulus can be provided to athletic males when loads of 45–80% 1RM HPC are prescribed for the HHP. In contrast, peak force at 30% 1RM HPC was statistically lower than the peak force at 45, 65, and 80% 1RM resulting in 8.2, 8.9, and 10.8% lower force, respectively. A potential explanation of this finding may relate to the force-velocity relationship; the lowest amount of force was produced at 30% 1RM HPC, and the highest peak velocity was produced at the same load, as generally expected (8). It was possible that differences in exercise technique existed across the loads examined, which might result in lower force production. However, because previous research has not examined the impact of load on peak force production during the HHP, it is difficult to make comparisons with other research findings.

There were statistical differences in peak velocity across the loads examined with loads of 30 and 45% 1RM HPC producing statistically greater peak velocity than both 65 and 80% 1RM HPC. More specifically, the peak velocity at 30% 1RM HPC was 14.1 and 19.8% greater than the peak velocity at 65 and 80% 1RM HPC, respectively. In addition, the peak velocity at 45% 1RM HPC was 9.1 and 14.9% greater than the peak velocity at 65 and 80% 1RM HPC, respectively. It seems that practitioners seeking to improve the velocity of a loaded triple extension movement should prescribe loads between 30 and 45% 1RM HPC.

Although much research has investigated the load that produces the greatest peak power during the power clean and its variations has focused on either the power clean from the floor (3,5–7) or HPC (17,18), only 3 studies (30,31,33) examined the load that produces the greatest peak power for the HHP exercise. This study demonstrated that the greatest peak power during the HHP occurred at 45% 1RM HPC, which is similar to previous findings (30,31). However, as previously noted, peak power at 45% 1RM HPC was not statistically different from the peak power at 30% 1RM HPC. The findings of this study are also similar to those of Thomas et al. (33) who indicated that the greatest peak power during the HHP occurred at 40% of their 1RM HHP. However, this value was not statistically different from the peak power produced at 30, 50, or 60% 1RM HHP. It should also be noted that the loads that maximized peak power during the HHP in this study are similar to other weightlifting derivatives that eliminate the catch phase, namely the jump shrug (greatest peak power at 30% 1RM HPC) (26,30,31) and midthigh clean pull (greatest peak power at 40% 1RM power clean) (4). From a practical standpoint, it seems that loads between 30 and 45% 1RM HPC or between 30 and 60% 1RM HHP could be prescribed for the greatest peak power production during the HHP. However, practitioners should be wary that these loads should not be the only loads implemented because previous research has indicated that "optimal loads" may be specific to the lifter plus bar system (4–7,26,27,30,31), barbell (13,22), and in relation to certain joints (19–21) during weightlifting movements. Thus, practitioners should prescribe multiple loads through the incorporation of warm-up sets, down sets, and heavy vs. light days to further develop load-power characteristics (8).

Because it may be impractical to perform a 1RM HHP in an athletic setting, or if the HPC is not an exercise that is currently prescribed within the training program, practitioners may need an alternative reference to prescribe loads for the HHP. A simple option would be to prescribe loads relative to the body mass of their athletes. In this study, the loads of 30 and 45% 1RM HPC corresponded to approximately 39 and 58% of the body masses of the subjects, respectively. Athletes in this study were already familiar with the HPC however, so the percentage of body mass recommended above may be too high for an athlete with little experience with weightlifting variations. It should be noted that an athlete's relative strength may also determine the loads that can be prescribed during the HHP. Previous research has indicated that the load that maximizes power for an athlete may occur at a greater percentage of 1RM as compared with their weaker counterparts (25). Therefore, as an athlete gets stronger, strength and conditioning practitioners may be able to prescribe greater loads that will maximize power production. As with any exercise, it is recommended that practitioners should closely monitor the technique of their athletes during the HHP before prescribing heavier loads. Further research on how loading affects peak power during the HHP is needed to provide more insight on this topic.

This is the first study that has assessed the force at peak power and velocity at peak power at different loads during the HHP. The rationale behind analyzing force at peak power and velocity at peak power is that insight can be provided on the contributing factors to peak power production during the HHP. The force at peak power at 80% 1RM HPC was statistically greater than all of the other loads examined. However, it should be noted that force at peak power values did not range any more than 105 N between the loads of 45, 65, and 80% 1RM HPC, suggesting that external loads that were moderate to high intensity (45–80% 1RM HPC) did not alter force at peak power to a great extent. This is confirmed by the effect sizes that only displayed small effects between the previously mentioned loads. Therefore, it seems that after the increase from 30% 1RM HPC, force production was similar, irrespective of the maximal effort with increasing loads. This is despite greater resultant velocities at lighter loads and a decreased time to produce force. These findings give rise to the belief that force at the instant peak power occurs may not be the major contributor to the differences in peak power production during the HHP across loads. However, it is important to note that this finding only applies to the instant peak power occurs and does not necessarily reflect the forces preceding this point.

On examination of the velocity at peak power, moderate to large effect sizes were displayed between loads, suggesting that the external load altered the velocity at peak power to a greater extent than force at peak power. This finding indicates that velocity at the instant peak power occurs may be a larger contributor to peak power during the HHP exercise, which is similar to previous findings with another weightlifting variation (26). The greatest value of velocity at peak power occurred at 30% 1RM HPC but was not statistically different from the value that occurred at 45% 1RM HPC. However, the velocities at peak power produced at 30 and 45% 1RM HPC were statistically greater than the velocities at peak power at both 65 and 80% 1RM HPC. More specifically, the velocities at peak power at 30 and 45% 1RM HPC were 11.0 and 7.5% greater than the velocity at peak power at 65% 1RM HPC and 15.6 and 12.1% greater than the velocity at peak power at 80% 1RM HPC, respectively.

Because no other study has investigated the force at peak power or velocity at peak power during the HHP, it is recommended that future research should examine these variables during the HHP and other weightlifting variations to provide insight on the contributing factors of peak power production. Furthermore, information about impulse and rate of force development leading up to the point in time that peak power occurs would provide a greater understanding of what contributes to peak power in the HHP and other weightlifting variations.

The randomized order of the exercise sets may be a potential limitation to this study. When training with the HHP, it is likely that athletes will perform warm-up sets using loads of increasing intensity. To eliminate an order effect (potentiation or fatigue) and to isolate impact of the load on the variables of interest, this study randomized the order of the loads. Future research should consider performing a similar study while progressively increasing the loads to replicate a typical resistance training session. Another potential limitation of this study may be the use of loads that were relative to each subject's 1RM HPC instead of their 1RM HHP. As previously mentioned, it may be impractical to perform a 1RM HHP test in an athletic setting. Therefore, loads may be prescribed based on the body mass of each subject as an initial starting point.

Practical Applications

The results of this study demonstrate that peak force, peak velocity, peak power, force at peak power, and velocity at peak power are affected by the external load during the HHP in athletic males. Increases in loading during the HHP have little influence on the peak force developed during the movement. However, the external load plays a larger role in determining the peak velocity of the lifter plus bar system. As indicated by the force at peak power and velocity at peak power, velocity at the instant peak power occurs seems to be a greater contributing factor over force to peak power production during the HHP. Therefore, the training emphasis of practitioners during the HHP should be placed on improving the lift velocity of their athletes to enhance their explosiveness and by extension, their power development. Peak power production during the HHP was not statistically different between 30 and 45% 1RM HPC, suggesting that these loads may provide the optimal training stimulus to athletes using this exercise. However, multiple loads should be prescribed through the incorporation of warm-up sets, down sets, and heavy vs. light days. Because the external load affected each variable examined, it seems that specific loads should be prescribed during the HHP to meet the current training goals of athletes.

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