Changes in Power Output following 6 weeks of Jump Shrug Training with a Hexagonal Barbell or an Olympic Barbell in Adolescent American Football Players

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ABSTRACT

This study examined changes in power outputs and sprint performance following a 6 week, 2 sessions per week, jump shrug training intervention using loads of 15, 30, and 45% of body weight (BW) with a Hexagonal Barbell (Hbar) or an Olympic barbell (Obar). **Methods** The Hbar group (n = 14, age 16.0 ± 0.6 years; body mass 80.6 ± 16.0 kg), the Obar group (n = 11, age 16.3 ± 0.4 years; body mass 76.6 ± 16.8 kg), and the control group (n = 5, age 16.4 ± 0.5 years; body mass 65.3 ± 10.3 kg) performed pre- and post-intervention tests: three countermovement jumps (CMJ), three jump shrugs at each loads of 15, 30, and 45% BW, and three 20-m sprints. Mean W/kg and peak W/kg power was measured for all jumps with a linear positional transducer (GymAware). 10-m and 20-m sprint times were recorded with photocells (TC-Timing System). **Results** Split plot ANOVAs ($p < 0.05$) (time × group) showed significant increase of 14.38% and 16.19% in mean W/kg at 15 and 30% BW, and a 15.91% increase in peak W/kg at 30% BW in the Obar group. The Hbar group decreased 6.34 % in mean W/kg at 45% BW. No changes in 10-m and 20-m sprint performance were found. **Conclusion** A six-week Obar jump shrug training intervention enhances lower-extremity power, however, did not improve sprint performance.

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KEYWORDS

Pre-season preparation, jump shrug, hexagonal barbell, power training, ballistic exercise, loaded jumping

Introduction

To enhance muscular power output, which is a vital part of athletic performance, loaded jumps and throws, olympic lifts, and their derivatives, appear to be the most effective training method, and is proposed to lead to increased training adaptations in muscular power output (Baker, 2001; Kawamori & Haff, 2004; Wilson, Newton, Murphy, & Humphries, 1993). Ballistic training methods such as loaded jumps and olympic lift derivatives e.g. the jump shrug, are often used in athletic power training programs due to the multi-joint movement pattern in jumping, which mimics lower body flexion and extension typically used in sprinting (Feeney, Stanhope, Kaminski, Machi, & Jaric, 2016; T. J. Suchomel, Comfort, & Stone, 2015; Ullrich, Pelzer, & Pfeiffer, 2017). Loturco et al., (2015) showed that sprinting speed is correlated with loaded and unloaded vertical jumping performance. The loaded jumps are transferable in sports such as rugby and American football, where external forces (body mass of the opponent) have to be overcome, therefore jumping with additional loads may yield superior performance outcomes in comparison to jumping against one´s own body mass (Haff & Nimphius, 2012). For instance, 10 weeks of loaded jump training with loads corresponding to 10% of body weight (BW) was shown to be superior in training adaptations and performance variables in comparison to unloaded jumps (Khlifa et al., 2010). Research suggests that countermovement loaded jumps are limited to around 30-40% of the individual's body mass since higher loads may cause altered jumping patterns (G. Markovic, Vuk, & Jaric, 2011). However, García-Ramos et al. (2016) found that the optimal load range for power output in loaded squat jumps occurred at 25-50% BW, whereas, Suchomel et al. (2013) found that loads of 30-60% BW in the jump shrug was optimal in peak power production. In addition, Kipp et al. (2016) found that optimal peak power production during the jump shrug corresponded to approximately 37.5-62.5% BW, which is in agreement with the findings of García-Ramos et al. (2016) and Suchomel et al. (2013). In addition, a previous unpublished study investigated power outputs in the jump shrug at loads 0, 15, 30, 45, and 60% BW and saw a trend towards an optimal power zone with loads of 15, 30, and 45% BW (Rysgaard, Strøm, & Sørensen, 2017) (unpublished). Loaded jumps and training with loads in the optimal power zone may yield a superior training adaptation (Kipp et al., 2016; Loturco et al., 2016; Ullrich et al., 2017). In addition, loaded jumps and olympic lift derivatives are lower in skill demand, and may be similar or superior in developing explosive performance, than olympic lifts (Kipp et al., 2016; T. J. Suchomel & Sole, 2017).

Several types of loaded jump have been used across the literature such as: barbell squat jumps, weighted vest jumps, barbell jump shrugs, and hexagonal bar jumps (Khlifa et al., 2010; McBride, Triplett-McBride, Davie, & Newton, 2002; Oranchuk, Robinson, Switaj, & Drinkwater, 2017; T. J. Suchomel et al., 2015). By using the Hexagonal barbell (Hbar), the lifter places less stress on the lower back (Malyszek et al., 2017; Swinton, Stewart, Agouris, Keogh, & Lloyd, 2011) as the bar allows for the center of mass of the resistance to be aligned closer to the center of mass of the body (Camara et al., 2016). When using the Hbar, the lifter has a more upright posture through the motion compared to using a standard Olympic barbell (Obar) where the lifter is placed behind the Obar. In addition, using the Hbar, the lifters forearms are in a neutral position in comparison to the pronated or supinated grip using the OBar. This neutral forearm and hand position in the Hbar allows for less stress on the wrists, elbows, and biceps (Gentry, Pratt, & Caterisano, 1987; Malyszek et al., 2017). Moreover, Swinton et al. (2011) compared the kinematics and kinetics of the deadlift between the Hbar and Obar, and found that the subjects were able to lift a heavier 1RM in the Hbar than the Obar, yet Camara et al. (2016) did not find a difference in 1RM deadlift between the Hbar and the Obar. In addition, Malyszek et al. (2017) did not find differences in ground reaction force between the bars in the mid-thigh pull and deadlift. However, both Swinton et al. (2011) and Camara et al. (2016) found that the Hbar produced significant higher peak power, peak force, and peak velocity values than the Obar, which demonstrates that the choice of barbell has a significant effect on the output variables, where the Hbar seems to be more effective at developing maximal force, power, and velocity. In addition, due to less strain on the lumbar spine (Swinton et al., 2011), and the barbell being placed closer to the subject's center of mass, it could be speculated that jump shrugs with the Hbar compared to jump shrugs with the Obar would results in greater performance outputs hence the results from Swinton et al. (2011) and Camara et al. (2016).

Researchers have found that neural (Moritani & DeVries, 1979; Aagaard, 2003) and muscle architectural changes (Blazevich, Gill, Bronks, & Newton, 2003; Seynnes, de Boer, & Narici, 2007; Ullrich, Pelzer, Oliveira, & Pfeiffer, 2016) may occur within four to six weeks of training (Ullrich et al., 2016, 2017). Four to six weeks of high intensity power training twice per week might be an optimal time frame for the central nervous system to be stressed enough for adaptations without excessive strain or fatigue (Adams, O'Shea, O'Shea, & Climstein, 1992). Therefore, short-term loaded jump training might induce neuromuscular adaptations after four to six weeks of training (Blazevich et al., 2003; Ullrich et al., 2016, 2017).

The present study set out to examine the training adaptations between the Hbar and the Obar in: countermovement jump (CMJ), power production in jump shrug at 15, 30 and 45% BW, and 10-, and 20-m sprint times after six weeks of jump shrug training in adolescent American football players.

It is hypothesized 1) that both training groups will improve in power outputs and 2) sprint performance after 6 weeks of jump shrug training. In addition, it is hypothesized 3) that the Hbar group will experience a greater training response compared to the Obar group and control group.

Methods

Experimental approach to the problem

This study compared power adaptations in the jump shrug at 15, 30, and 45% BW load following a six-week training intervention with either an Obar or a Hbar. The study design consisted of: pre-test, intervention, and post-test. At the pre- and post-test, the subjects performed: a standardized warm up, three CMJs, and three jump shrugs at each load: 15, 30, and 45% BW. On a separate day the subjects performed three 20-m sprint tests. The intervention was six weeks with two training sessions per week for a total of 12 sessions with a total of 180 jump shrugs (figure 1).

Subjects

The study was conducted with 25 football players and 5 basketball players divided into three groups: Hbar group (n = 14, age 16.0 ± 0.6 years; body mass 80.6 ± 16.0 kg), Obar group (n = 11, age 16.3 ± 0.4 years; body mass 76.6 ± 16.8 kg) and the basketball players being the control group (n = 5, age 16.4 ± 0.5 years; body mass 65.3 ± 10.3 kg). A matched subjects design was used that paired subjects based on body mass and thereafter randomly assigned them to either the Obar or Hbar group. 12 football players and 4 basketball players (n = 42) were excluded due to injuries and sickness not affiliated with study. All subjects had little to no experience in resistance and plyometrics training, attended the BGI-academy, and all of them were living on the school, thus sharing similar eating and sleeping habits. Simultaneously with the training intervention the subjects had three weekly American football or basketball training sessions, as part of the weekly school routine. Testing and training was

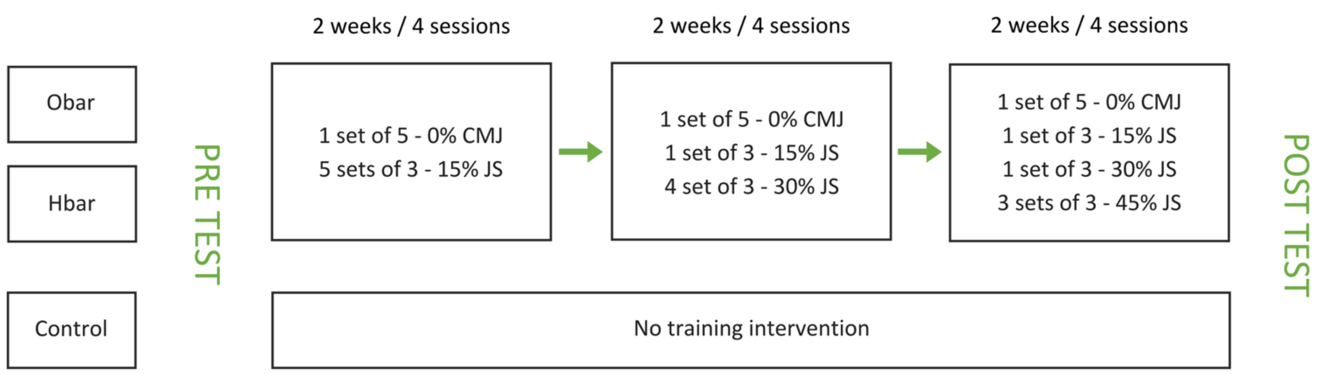

Figure 1. Study design for a six-week loaded jump shrug training period with an Obar, Hbar, and control group.
All subjects exercised with 1 set of 5 unloaded CMJ jumps and 5 sets x 3 repetitions loaded jump shrugs (JS). After two weeks, load intensity was increased. 1-2 week: 5 sets of 3 reps with 15% BW load, 3-4 week: 1 set of 3 reps with 15% BW and 4 sets of 3 reps with 30% BW, 5-6 week: 1 set of 3 reps with 15% BW, 1 set of 3 reps with 30% BW, and 3 sets of 3 reps with 45% BW.

performed during preseason. A written consent was signed by the BGI Academy.

Execution of the jump shrug

The jump shrug is a countermovement jump with a shrug at the top of the trajectory, similar to the second pull known from weightlifting exercises (DeWeese, Serrano, Scruggs, & Burton, 2013; T. J. Suchomel et al., 2015). During test and training intervention, subjects were instructed to "jump as high as possible while simultaneously shrugging the shoulders" as recommended by T. Suchomel and DeWeese (2014). Technique was monitored and coached throughout the tests and the intervention.

Familiarization

A high degree of reliability can be achieved with the best of three attempts in vertical jump and 10- and 20-m sprint performance without further familiarization (Moir, Button, Glaister, & Stone, 2004). Therefore, a familiarization session was not implemented prior to test sessions in the present study.

Test procedures

Warm up

Before each test session a standardized specific warm-up for each test protocol was performed to reduce the risk of injury (Woods, Bishop, & Jones, 2007).

Sprint test

Subjects performed a series of controlled lower body dynamic exercises at a jogging pace for 20 repetitions with a walk-back recovery (Fletcher & Jones, 2004). Sprint performance was measured in a straight line, and running time recorded at 10- and 20-m. As inspired by Duthie et al. (2006), subjects started each sprint in a self-chosen position, however, the position was to be used across all sprints. The subjects initiated the runs when they were ready. Each subject performed three runs of maximal effort with two minutes of seated rest in between runs.

Countermovement jump

The warm-up protocol consisted of 1 set of 5 CMJs with a load of approximately 10% bodyweight (Burkett, Phillips, & Ziuraitis, 2005), where the Obar group used a lighter barbell while the Hbar group used dumbbells to accommodate for lower loads. CMJs were executed with hands akimbo and the GymAware tethered to the hand. The amplitude of the countermovement was self-chosen, and the subjects were instructed to jump for maximal height (Loturco et al., 2016). Each subject performed three CMJs of maximal effort with two minutes of seated rest in between.

Jump shrug

A linear progression in the external load was implemented to replicate a typical resistance training session, where the subjects started with the CMJ and progressed into loaded jump shrugs. The following rest periods between jump shrug reps were used: one minute between reps with 0 and 15% load, one and a half minute between reps at 30% load, and two minutes between reps at 45% load. Moreover, a rest period of two minutes between loads was used (Suchomel and Sole 2017).

Experimental training intervention

The present study increased intensity every other week for a period of six weeks with two supervised training sessions per week, to allow for sufficient recovery (O´Shea, 1979). Volume was held constant at 20 jumps each session - 5 CMJs and 15 jump shrugs. Each training session started with a dynamic warm up session (Fletcher & Jones, 2004), followed by one set of 5 CMJs arms akimbo. Week 1 and 2 consisted of 5 sets with 3 reps of 15% BW as load. Week 3 and 4 consisted of 1 set of 3 jumps with 15% BW load and 4 sets of 3 reps of 30% BW load. Week 5 and 6 consisted of 1 set of 3 jumps with 15% BW load, 1 set of 3 jumps with 30% BW load, followed by 3 sets with 3 reps of 45% BW load. To be included in the present study the subject had to complete at least 11 out of 12 training sessions within the six-week intervention period.

Instrumentation and data processing

The present study used the GymAware (Kinetic Performance Technology, Mitchell ACT, Australia) to collect data in jump shrugs and CMJs. The GymAware is a linear positional transducer, which measures angular position by recording a spinning wheel with an infrared laser at a variable sampling rate of 115,200 Hz with a down sampling of 50 Hz. The GymAware was chosen for practical reasons, and is a reliable field instrument to assess power output (O'Donnell, Tavares, McMaster, Chambers, & Driller, 2018). GymAware data was exported in relative values (W/kg) to Microsoft Excel® 2016 and sorted in values of interest and loads. Time intervals for sprint times were collected using the wireless TC-Timing System (Brower Timing Systems, Draper, Utah), which were set at approximately mid shin height and were placed at the 0-, 10-, and 20-m marks in a basketball gym. Sprint times were obtained and manually exported from the handheld TC-Timing device into Microsoft Excel® 2016.

Statistical analysis

The average of three: CMJs, loaded jump shrugs at loads 15, 30, 45% BW, and 10- and 20-m sprint times were used for subsequent statistical analysis. Statistical analyses were performed using SPSS (version 25.0; SPSS Inc., Chicago, IL), and the statistical significance was set at $\alpha = 0.05$. A Shapiro-Wilk test was used to determine normal distribution for all variables of interest: mean relative power (mean W/kg) and peak relative power (peak W/kg), difference between pre- and post-results in percentage (Δ%), and 10- and 20-m sprint times. During initial analysis, a visual inspection of the data revealed errors in the collection of the CMJ data, and thus the data was excluded from further analysis and discussion. Whether the data was normally distributed a Split-Plot (time (pre or post) × group (Obar group, Hbar group, or control) ANOVA was conducted due to the robustness of the ANOVA (Schmider, Ziegler, Danay, Beyer, & Bühner, 2010). Split-Plot ANOVAs was conducted on mean W/kg and peak W/kg at 15, 30, and 45% BW loads, and on average 10- and 20-m sprint times to compare the difference between pre- and post-training results within, and between groups. In addition, One-way ANOVAs were conducted to compare Δ% (equation 1) between groups on the 15, 30, and 45% BW power outputs and on the average 10- and 20-m sprint times.

$$\Delta\% = \frac{Post - Pre}{Post} * 100\ (1)$$

A Bonferroni post hoc test was employed to identify pairwise differences between means if significant values were found. Effect sizes (ES) were calculated for the major outcomes to quantify the magnitude of the difference between means with equation 2:

$$\text{ES} = \frac{mean\ Post - mean\ Pre}{SD_{pooled}} * 100\ (2)$$

Results

Pre-intervention comparison showed no significant difference between groups in BW. In addition, no significant difference in BW post-intervention were found within and between all three groups. The subjects had a training compliance of 99,4%.

Sprint times

A post hoc power analysis showed no significant differences between pre- and post-intervention results in 10- and 20-m sprint times within groups. Moreover, there were no significant differences between groups in either pre- or post-intervention 10- and 20-m sprint times. In addition, Δ% from pre- to post-intervention between groups did not differ significantly (table 1 and figure 2).

Within groups (15, 30, and 45% BW)

Mean power W/kg

A post hoc power analysis showed significant differences between pre- and post-intervention results in mean W/kg in the Obar group at load 15 and 30% BW, where mean scores increased significantly by 14.38 ($p = 0.013$) and 16.19% ($p = 0.041$), respectively. Furthermore, a significant decrease of 6.34% ($p =$ 0.003) was found in the Hbar group at 45% BW load (table 2 and figure 3).

Peak power W/kg

The Obar group increased peak W/kg significantly ($p = 0.009$) in 30% BW load with 15.91%, and the control group increased peak W/kg significantly ($p = 0.043$) by 8.98% in the 45% BW load (table 3 and figure 4).

TABLE 1. Average sprint times (mean ± *SD*) in seconds for the Obar, Hbar, and control group across 10- and 20-m.

	10 m			20 m		
	Pre	*Post*	*Δ%*	*Pre*	*Post*	*Δ%*
Obar	1.76 ± 0.10	1.78 ± 0.09	1.28 ± 2.50	3.09 ± 0.17	3.09 ± 0.15	0.13 ± 1.51
Hbar	1.79 ± 0.09	1.79 ± 0.08	0.19 ± 3.70	3.12 ± 0.17	3.10 ± 0.16	-0.47 ± 1.74
Control	1.67 ± 0.08	1.73 ± 0.03	3.49 ± 0.70	2.97 ± 0.13	3.03 ± 0.06	1.98 ± 3.30

Δ% = change in percentage from pre to post

15% load between groups

Statistical analysis showed no differences between groups in either pre- or post-intervention 15% BW mean W/kg or peak W/kg values. Moreover, Δ% from pre- to post-intervention in mean W/kg or peak W/kg values did not differ between groups at 15% BW loads.

30% load between groups

Statistical analysis showed no differences between groups in either pre- or post-intervention 30% BW mean W/kg or peak W/kg values. Moreover, Δ% from pre- to post-intervention in mean W/kg or peak W/kg values did not differ between groups at 30% BW loads.

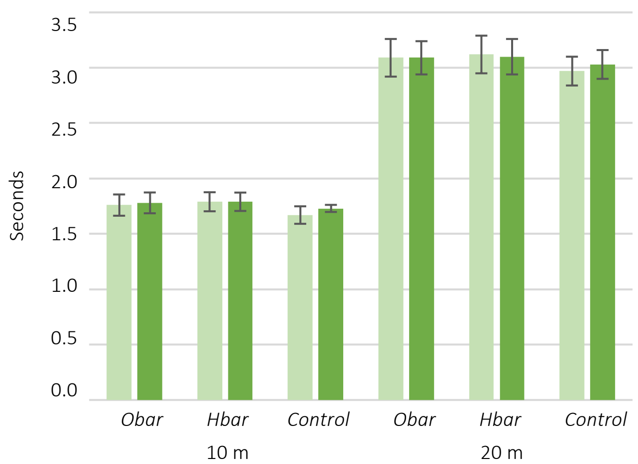

Figure 2. Pre- (♦) and post- (♦) intervention sprint times for all groups across 10- and 20-m.
Sprint times with mean values and error bars.

45% load between groups

Statistical analysis showed significant differences between groups in pre-intervention 45% BW mean W/kg and peak W/kg values. The Hbar group showed significantly higher mean W/kg and peak W/kg values than both the Obar (p = 0.002, 0.003) and control group (p = 0.013, 0.005). However, no differences between groups in post-intervention 45% BW mean W/kg or peak W/kg values were found. In addition, a significant difference between the Obar and Hbar group in Δ% was found, where the Obar group improved 15.31 % in mean W/kg and the Hbar group decreased 6.34 % in mean W/kg.

TABLE 2. Power adaptations (mean ± *SD*) in jump shrug in average mean W/kg from pre- to post-intervention.

	% BW	Pre-intervention	Post-intervention	Δ%	ES
Obar	15	36.52 ± 7.37	41.33 ± 7.05*	14.38 ± 15.68	0.64
	30	30.35 ± 6.77	34.69 ± 7.01*	16.19 ± 23.75	0.60
	45	26.33 ± 4.47 ⅄	29.68 ± 5.71	15.31 ± 27.54	0.62
Hbar	15	38.31 ± 8.70	37.93 ± 5.17	2.26 ± 18.62	-0.05
	30	36.56 ± 7.25	36.44 ± 5.62	0.94 ± 11.52	-0.02
	45	34.34 ± 5.56	32.06 ± 4.97*	-6.34 ± 6.54	-0.39
Control	15	33.17 ± 9.25	34.32 ± 9.02	6.38 ± 22.62	0.12
	30	29.01 ± 7.81	31.53 ± 6.98	10.53 ± 13.72	0.33
	45	25.98 ± 5.36 ⅄	25.76 ± 7.12	-1.75 ± 6.59	-0.03

* = Significant difference from pre-intervention ($p < 0.05$)
⅄ = significant different than Hbar under same load at pre-intervention ($p < 0.05$)
% BW = Percentage load of body weight
Δ% = change in percentage from pre to post
ES = Effect size (Hedges-G low sample corrected)

Discussion

The main object of the present study was to investigate the difference in power outputs between the Obar and Hbar after six weeks jump shrug training at loads of 15, 30, and 45% BW. A comparison of pre- and post-intervention results found a significant increase of 14.38% and 16.19% in mean W/kg outputs at 15 and 30% BW (p = 0.013, 0.041), and 15.91% increase in peak W/kg at load 30% BW (p = 0.009) in the Obar group. The Hbar group did not increase significantly in power output, however, experienced a significant change of -6.34 % (p = 0.003) in mean W/kg at 45% BW. Both groups received the same amount of training, the same number of jumps, and used the same relative load based on BW. Thus, our data suggest that short-term loaded jump shrug training can be effective when using the Obar, but not the Hbar denying hypothesis 1) and 3).

The control group increased peak W/kg significantly (p = 0.043) by 8.98% with 45% BW load. A reason for this change might be the small group (n = 5) which influences the results and allow outliers to affect the results greatly.

Differences between Obar and Hbar

The increase of 14.38-16.19% in power outputs in the Obar group are in line with results reported in several studies (Khlifa et al., 2010; Pelzer, Ullrich, Endler, Rasche, & Pfeiffer, 2017; Teo, Newton, Newton, Dempsey, & Fairchild, 2016; Ullrich et al., 2017). Ullrich et al. (2017) reported a significant increase of 5 to 16% in CMJ height. Khlifa et al. (2010) reported significant and superior increase of 12.2% in CMJ height after 10 weeks of loaded jumps with 10-11% BW in comparison to unloaded jumps. Moreover, Teo et al. (2016) showed 5-8% higher CMJ peak power after 8 weeks of loaded plyometric training. Finally, Pelzer et al. (2017) found a significant increase of 5-16% in CMJ height after 6 weeks (18 sessions) of training and reported significant increases from pre- to post-maximal CMJ power in 5, 10, 15, 20, 25, and 30% BW loads.

However, these findings do not comply with the results in the Hbar group, which showed no significant changes post-intervention, except a significant change in mean W/kg of -6.34%. The decrease in mean W/kg in the Hbar group might be due to the higher load altering jumping techniques as suggested by Feeney et al. (2016) and Markovic and Jaric (2007). Applying loads closer to the subject's center of mass through training vests has been seen to improve jumping performance and power outputs (Khlifa et al., 2010; Ullrich et al., 2017), however, the Hbar group did not increase in power outputs, even though the Hbar allows for the load to be placed closer to the subjects center of mass in comparison to the Obar. Differences between bars in knee, ankle, and hip range of motion were not tested for, however, the differences in results between groups may be due to the bar choice affecting joint and muscle characteristics during the jump shrug.

TABLE 3. Power adaptations (mean ± *SD*) in jump shrug in average peak W/kg from pre- to post-intervention.

	% BW	Pre-intervention	Post-intervention	Δ%	ES
Obar	15	65.69 ± 13.52	72.13 ± 11.40	11.24 ± 14.76	0.50
	30	55.82 ± 10.67	63.75 ± 10.01*	15.91 ± 18.53	0.71
	45	50.34 ± 7.88 ⅄	56.85 ± 7.95	15.62 ± 26.87	0.76
Hbar	15	69.69 ± 13.55	70.70 ± 9.21	3.71 ± 17.36	-0.08
	30	67.30 ± 14.21	68.76 ± 10.82	3.65 ± 12.02	-0.11
	45	62.88 ± 9.81	62.51 ± 10.94	-0.69 ± 5.91	-0.03
Control	15	57.64 ± 11.13	60.01 ± 5.39	6.04 ± 13.93	0.27
	30	53.24 ± 5.15	57.27 ± 7.22	7.65 ± 9.55	0.61
	45	47.71 ± 3.35 ⅄	52.26 ± 9.68*	8.98 ± 12.66	0.59

* = Significant difference from pre-intervention ($p < 0.05$)
⅄ = significant different than Hbar under same load at pre-intervention ($p < 0.05$)
% BW = Percentage load of body weight
Δ% = change in percentage from pre to post
ES = Effect size (Hedges-G low sample corrected)

For instance, Camara et al. (2016) revealed through EMG that amplitude values from the vastus lateralis were significantly greater for the Hbar, than the Obar in the deadlift, indicating a more quadriceps-dominant movement when using the Hbar in

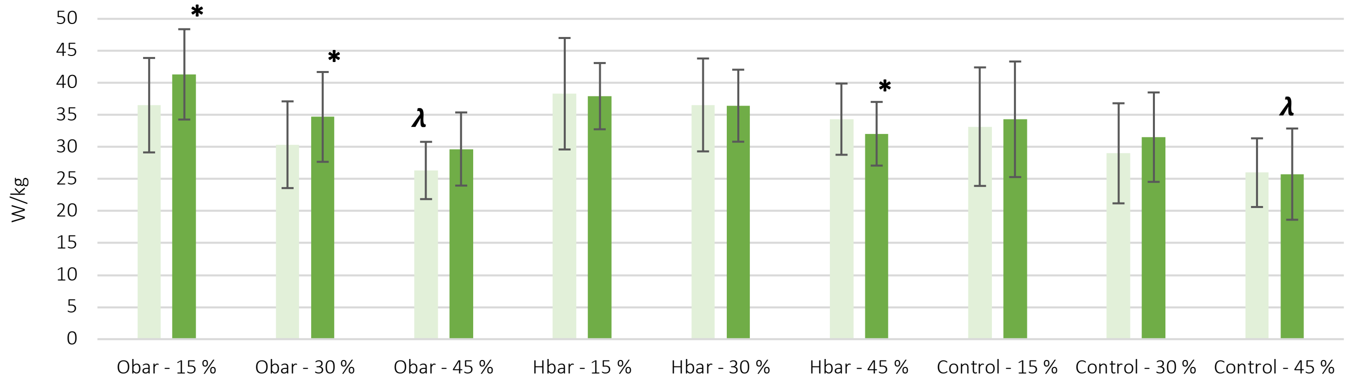

Figure 3. Pre- (♦) and post- (♦) intervention normalized mean values W/kg for all three groups at each load.
* = significant different from pre-intervention in same group at same load ($p < 0.05$). **λ** = significant different than Hbar under same load at pre-intervention ($p < 0.05$).
Sprint times with mean values and error bars.

comparison to the Obar. The less stress on the spine (Malyszek et al., 2017), the ability to lift heavier 1RM deadlift (Swinton et al., 2011), and the significantly higher peak power, peak force, and peak velocity values using the Hbar, were thought to lead to a greater training adaptation (Swinton et al., 2011; Camara et al., 2016). However, where the upright position and less strain on the lumbar spine may be an advantage during deadlifts, the results (table 2 and 3, figure 3 and 4) may indicate that, the greater spine and hip flexion, when using the Obar, may be advantageous during jump-shrug. The more upright position with the Hbar may be advantageous at higher loads, as the Hbar group had significant higher mean W/kg (p = 0.002; p = 0.013) and peak W/kg (p = 0.003; p = 0.005) power outputs pre-intervention at 45% BW load in comparison to the Obar and control group respectively. These findings are in line with previous findings, who also found that the Hbar produced greater force, power, and velocity in deadlift and jump squat compared to conventional deadlift and jump squat with an Obar (Malyszek et al., 2017; Swinton et al., 2011; Swinton, Stewart, Lloyd, Agouris, & Keogh, 2012). However, post-intervention results showed no differences between groups.

In the vertical CMJ, Vanezis and Lees (2005) found a larger percentage contribution of the hip joint (41-43%) in comparison to the knee joint (29-31%). Moreover, Vanrenterghem, Lees, and Clercq (2008) reported a significant correlation between peak hip power and jump performance in both the upright and normal vertical CMJ. However, a more upright position, as seen with the Hbar, changes the hip joint contribution and thereby performance (Vanrenterghem et al., 2008). Vanrenterghem et al. (2008) reported that a more upright position in comparison to a forward trunk lean, leads to a significant decrease of 10% in CMJ height as power joint distribution changes: a decrease of 37% in Hip joint power, an increase of 13% in knee joint power, and the ankle joint power did not change. Moreover, Luhtanen and Komi (1978) reported that trunk extension accounted for approximately 10% of jump performance. In addition, Ravn et al. (1999) also reported the importance of trunk positioning, where a 7.6% decrease in performance was seen when comparing a ballet-specific CMJ, keeping the upper body upright, with a normal vertical CMJ. The trunk positioning is vital for jump performance (Luhtanen & Komi, 1978; Ravn et al., 1999; Vanrenterghem et al., 2008), where especially hip power production is correlated to jump performance, but if the hip power is reduced due to the trunk positioning, the training adaptation may be reduced as well. It is possible that the Obar group were not affected by the higher strain on the lumbar spine, but were able to utilize the hip joint and the forward lean to their advantages in comparison to the more upright position induced by the Hbar (Luhtanen & Komi, 1978; Ravn et al., 1999; Vanrenterghem et al., 2008). The trunk position altered by the bar choice, leading to alteration in joint power, may be the

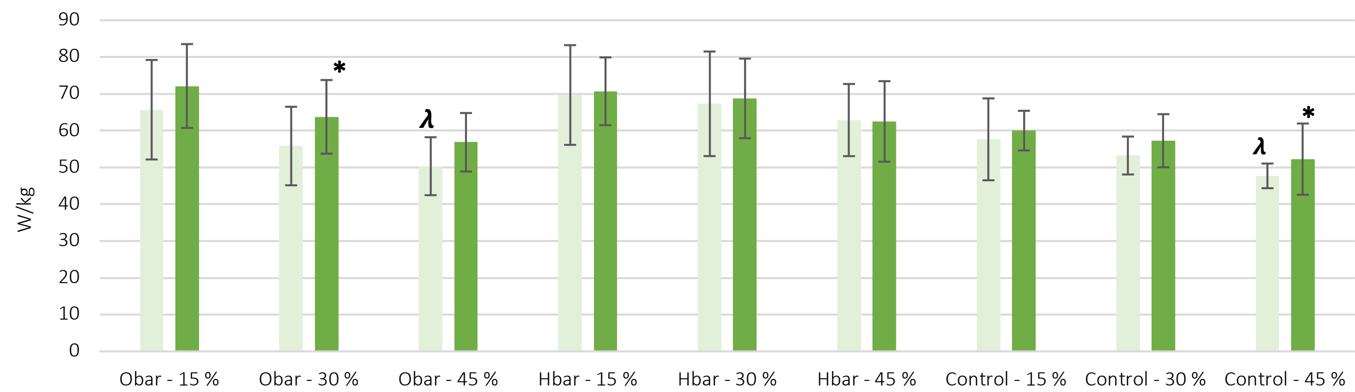

Figure 4. Pre- (♦) and post- (♦) intervention normalized peak values W/kg for all three groups at each load.
* = significant different from pre-intervention in same group at same load. ($p < 0.05$). **λ** = significant different than Hbar under same load at pre-intervention ($p < 0.05$).
Sprint times with mean values and error bars.

explanation for why the Obar group seem to improve, where the Hbar does not.

The decrease in power output from pre- to post-intervention at 45% BW load might be due to elbow flexing in the jump shrug. The 45% BW load is a relatively heavy load and thus the subjects might have flexed their elbows to compensate for the heavier load in the pre-intervention test (Feeney et al., 2016). At the post-intervention test, our supervised training intervention could potentially have adjusted the elbow flexion, resulting in a lower power output due to reduced displacement of the bar.

Sprint Times

The present study did not find any significant differences between sprinting times after the six-week training intervention (12 sessions, 20 jumps per session) in any of the groups denying hypothesis 2). A meta-analysis by Villarreal et al. (2012) including 26 studies and 56 ES highlighted the effects of plyometric training on sprint performance. Villarreal et al. (2012) found that to significantly improve sprint performance a <10 weeks, minimum 15 sessions, and high-intensity program with >80 jumps per session was recommended. In addition, utilizing jumps with horizontal displacement and sprint-specific plyometrics is recommended rather than using a singular form of jump training. Moreover, Villarreal et al. (2012) reported that using added weight in plyometrics was not beneficial in increasing sprint performance. Even though, the subjects in the Obar group experienced significant increase in power outputs, sprint times did not change significantly after the six-week intervention. Therefore, to optimize sprinting performance in a jump shrug training intervention, more running-like bounding and horizontal jumps, to increase training transfer should be included. In addition, more training sessions and more jumps per session might have been beneficial for the subjects to increase sprint performance.

Conclusion

In conclusion the main object of the current study was to investigate the difference between the Obar and Hbar after six weeks jump shrug training at loads of 15, 30, and 45% BW. This study found that power outputs were significantly increased at loads of 15-30% BW in the Obar group. However no significant increase was found in the Hbar group, in contrast, a significant decrease in power output at 45% BW load was found, suggesting that bar choice is essential. In addition, the results suggest that whether using the Obar or the Hbar, no changes in 10- and 20-m sprint performance were found. These results submit proof that a six-week jump shrug training intervention, with the Obar enhances lower-extremity power, however, did not improve sprint performance.

Further research

A biomechanical analysis of the jump shrug with different bars should be conducted to investigate potential differences in joint kinematics and kinetics, to determine whether load position can affect joint power outputs and segment coordination, since the bar choice seems to lead to different training adaptations. Additional research should be done in the estimation of suitable workloads in the jump shrug in regards of strength level. Loads based on BW fail to account for strength differences between subjects at similar body mass.

Practical application

Six weeks, two training session per week, Obar jump shrug training is sufficient to increase power outputs in adolescent American football players. Due to significant training adaptations after six weeks of Obar jump shrug training, Obar jump shrug is recommended over Hbar jump shrug which did not elicit positive significant training adaptations. Neither Obar or Hbar jump shrugs improved sprint performance, indicating that a sprint training intervention should include sprint specific jumps or training.

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References

Adams, K., O'Shea, J. P., O'Shea, K. L., & Climstein, M. (1992). Effect of Six Weeks of Squat, Plyometric and Squat-Plyometric Training on Power Production.pdf. *Journal of Applied Sport Science Research*, *6*(1), 36–41.

Baker, D. (2001). A series of studies on the training of high-intensity muscle power in rugby league football players. *Journal of Strength and Conditioning Research*, *15*(2), 198–209. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11710405

Blazevich, A. J., Gill, N. D., Bronks, R., & Newton, R. U. (2003). Training-Specific Muscle Architecture Adaptation after 5-wk Training in Athletes. *Medicine and Science in Sports and Exercise*, *35*(12), 2013–2022. https://doi.org/10.1249/01.MSS.0000099092.83611.20

Burkett, L. N., Phillips, W. T., & Ziuraitis, J. (2005). The best warm-up for the vertical jump in college-age athletic men. *Journal of Strength and Conditioning Research*, *19*(3), 673–676. https://doi.org/10.1519/15204.1

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. *Journal of Strength and Conditioning Research*, *30*(5), 1183–1188. https://doi.org/10.1519/JSC.0000000000001352

DeWeese, B. H., Serrano, A. J., Scruggs, S. K., & Burton, J. D. (2013). The Midthigh Pull. *Strength and Conditioning Journal*, *35*(6), 54–58. https://doi.org/10.1519/SSC.0b013e318297c77b

Duthie, G. M., Pyne, D. B., Ross, A. A., Livingstone, S. G., & Hooper, S. L. (2006). The Reliability of Ten-Meter Sprint Time Using Different Starting Techniques. *The Journal of Strength and Conditioning Research*, *20*(2), 246. https://doi.org/10.1519/R-17084.1

Feeney, D., Stanhope, S. J., Kaminski, T. W., Machi, A., & Jaric, S. (2016). Loaded vertical jumping: Force-velocity relationship, work, and power. *Journal of Applied Biomechanics*, *32*(2), 120–127. https://doi.org/10.1123/jab.2015-0136

Fletcher, I. M., & Jones, B. (2004). The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. *Journal of Strength and Conditioning Research*, *18*(4), 885–888. https://doi.org/10.1519/14493.1

García-Ramos, A., Stirn, I., Strojnik, V., Padial, P., De la Fuente, B., Argüelles-Cienfuegos, J., & Feriche, B. (2016). Comparison of the force-, velocity-, and power-time curves recorded with a force plate and a linear velocity transducer. *Sports Biomechanics*, *15*(3), 329–341. https://doi.org/10.1080/14763141.2016.1161821

Gentry, M., Pratt, D., & Caterisano, T. (1987). Strength Training Modalities - Introducing the Trap Bar.pdf. *NSCA Journal*, *9*, 54–55.

Haff, G. G., & Nimphius, S. (2012). Training Principles for Power. *Strength and Conditioning Journal*, *34*(6), 2–12. https://doi.org/10.1519/SSC.0b013e31826db467

Kawamori, N., & Haff, G. G. (2004). The Optimal Training Load for the Development of Muscular Power. *The Journal of Strength and Conditioning Research*, *18*(3), 675. https://doi.org/10.1519/1533-4287(2004)18<675:TOTLFT>2.0.CO;2

Khlifa, R., Aouadi, R., Hermassi, S., Chelly, M. S., Jlid, M. C., Hbacha, H., & Castagna, C. (2010). Effects of a plyometric training program with and without added load on jumping ability in basketball players. *Journal of Strength and Conditioning Research*, *24*(11), 2955–2961. https://doi.org/10.1519/JSC.0b013e3181e37fbe

Kipp, K., Malloy, P. J., Smith, J., Giordanelli, M. D., Kiely, M. T., Geiser, C. F., & Suchomel, T. J. (2016). Mechanical Demands of the Hang Power Clean and Jump Shrug. *Journal of Strength and Conditioning Research*, 1. https://doi.org/10.1519/JSC.0000000000001636

Loturco, I., Pereira, L. A., Kobal, R., Maldonado, T., Piazzi, A. F., Bottino, A., … Nakamura, F. Y. (2016). Improving Sprint Performance in Soccer: Effectiveness of Jump Squat and Olympic Push Press Exercises. *PLOS ONE*, *11*(4), e0153958. https://doi.org/10.1371/journal.pone.0153958

Loturco, I., Pereira, L. A., Kobal, R., Zanetti, V., Kitamura, K., Abad, C. C. C., & Nakamura, F. Y. (2015). Transference effect of vertical and horizontal plyometrics on sprint performance of high-level U-20 soccer players. *Journal of Sports Sciences*, *33*(20), 2182–2191. https://doi.org/10.1080/02640414.2015.1081394

Luhtanen, P., & Komi, P. V. (1978). Segmental contribution to forces in vertical jump. *European Journal of Applied Physiology and Occupational Physiology*, *38*(3), 181–188. https://doi.org/10.1007/BF00430076

Malyszek, K. K., Harmon, R. A., Dunnick, D. D., Costa, P. B., Coburn, J. W., & Brown, L. E. (2017). Comparison of Olympic and Hexagonal Barbells With Midthigh Pull, Deadlift, and Countermovement Jump. *Journal of Strength and Conditioning Research*, *31*(1), 140–145. https://doi.org/10.1519/JSC.0000000000001485

Markovic, G., & Jaric, S. (2007). Positive and negative loading and mechanical output in maximum vertical jumping. *Medicine and Science in Sports and Exercise*, *39*(10), 1757–1764. https://doi.org/10.1249/mss.0b013e31811ece35

Markovic, G., Vuk, S., & Jaric, S. (2011). Effects of jump training with negative versus positive loading on jumping mechanics. *International Journal of Sports Medicine*, *32*(5), 365–372. https://doi.org/10.1055/s-0031-1271678

McBride, J. M., Triplett-McBride, T., Davie, A., & Newton, R. U. (2002). The effect of heavy- vs. light-load jump squats on the development of strength, power, and speed. *Journal of Strength and Conditioning Research*, *16*(1), 75–82. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11834109

Moir, G., Button, C., Glaister, M., & Stone, M. H. (2004). Influence of Familiarization on the Reliability of Vertical Jump and Acceleration Sprinting Performance in Physically Active Men. *The Journal of Strength and Conditioning Research*, *18*(2), 276. https://doi.org/10.1519/R-13093.1

Moritani, T., & DeVries, H. A. (1979). Neural factors versus hypertrophy in the time course of muscle strength gain. *American Journal of Physical Medicine*, *58*(3), 115–130. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/453338

O'Donnell, S., Tavares, F., McMaster, D., Chambers, S., & Driller, M. (2018). The validity and reliability of the GymAware linear position transducer for measuring counter-movement jump performance in female athletes. *Measurement in Physical Education and Exercise Science*, *22*(1), 101–107. https://doi.org/10.1080/1091367X.2017.1399892

O´Shea, J. P. (1979). Superquality strength training for the elite field event athlete - shot put, discus, javelin and hammer throwers. *Track Field Quart. Rev*, *79*(2), 54–55.

Oranchuk, D. J., Robinson, T. L., Switaj, Z. J., & Drinkwater, E. J. (2017). Comparison of the Hang High-Pull and Loaded Jump Squat for the Development of Vertical Jump and Isometric Force-Time Characteristics. *Journal of Strength and Conditioning Research*, (April), 1. https://doi.org/10.1519/JSC.0000000000001941

Pelzer, T., Ullrich, B., Endler, S., Rasche, C., & Pfeiffer, M. (2017). A biomechanical comparison of countermovement performance after short-term traditional and daily-undulated loaded vertical jump training. *Journal of Sports Sciences*, *36*(16), 1–11. https://doi.org/10.1080/02640414.2017.1422627

Ravn, S., Voigt, M., Simonsen, E. B., Alkjaer, T., Bojsen-Møller, F., & Klausen, K. (1999). Choice of jumping strategy in two standard jumps, squat and countermovement jump--effect of training background or inherited preference? *Scandinavian Journal of Medicine & Science in Sports*, *9*(4), 201–208. https://doi.org/10.1111/j.1600-0838.1999.tb00234.x

Rysgaard, J. K., Strøm, J., & Sørensen, D. N. (2017). Optimal Loading for Maximal Power Output in Barbell Jump Shrugs in Untrained Adolescent American Football Players, (December,2017), 1–8. (Unpublished)

Sáez de Villarreal, E., Requena, B., & Cronin, J. B. (2012). The effects of plyometric training on sprint performance: a meta-analysis. *Journal of Strength and Conditioning Research*, *26*(2), 575–584. https://doi.org/10.1519/JSC.0b013e318220fd03

Schmider, E., Ziegler, M., Danay, E., Beyer, L., & Bühner, M. (2010). Is It Really Robust? *Methodology*, *6*(4), 147–151. https://doi.org/10.1027/1614-2241/a000016

Seynnes, O. R., de Boer, M., & Narici, M. V. (2007). Early skeletal muscle hypertrophy and architectural changes in response to high-intensity resistance training. *Journal of Applied Physiology (Bethesda, Md. : 1985)*, *102*(1), 368–373. https://doi.org/10.1152/japplphysiol.00789.2006

Suchomel, T., & DeWeese, B. (2014). The jump shrug: A progressive exercise into weightlifting derivatives. *Strength & …*, 43–47. Retrieved from http://journals.lww.com/nsca-scj/Abstract/2014/06000/The_Jump_Shrug___A_Progressive_Exercise_Into.12.aspx

Suchomel, T. J., Beckham, G. K., & Wright., G. A. (2013). Lower body kinetics during the jump shrug: impact of load. *Journal of Trainology*, *2*(December), 10–12. https://doi.org/10.17338/trainology.2.2

Suchomel, T. J., Comfort, P., & Stone, M. H. (2015). Weightlifting Pulling Derivatives: Rationale for Implementation and Application. *Sports Medicine*, *45*(6), 823–839. https://doi.org/10.1007/s40279-015-0314-y

Suchomel, T. J., & Sole, C. J. (2017). Power-time curve comparison between weightlifting derivatives. *Journal of Sports Science and Medicine*, *16*(3), 407–413. https://doi.org/10.1123/ijspp.2016-0147

Swinton, P. A., Stewart, A., Agouris, I., Keogh, J. W. L., & Lloyd, R. (2011). A biomechanical analysis of straight and hexagonal barbell deadlifts using submaximal loads. *Journal of Strength and Conditioning Research*, *25*(7), 2000–2009. https://doi.org/10.1519/JSC.0b013e3181e73f87

Swinton, P. A., Stewart, A. D., Lloyd, R., Agouris, I., & Keogh, J. W. L. (2012). Effect of Load Positioning on the Kinematics and Kinetics of Weighted Vertical Jumps. *Journal of Strength and Conditioning Research*, *26*(4), 906–913. https://doi.org/10.1519/JSC.0b013e31822e589e

Teo, S. Y. M., Newton, M. J., Newton, R. U., Dempsey, A. R., & Fairchild, T. J. (2016). Comparing the Effectiveness of a Short-Term Vertical Jump vs. Weightlifting Program on Athletic Power Development. *Journal of Strength and Conditioning Research*, *30*(10), 2741–2748. https://doi.org/10.1519/JSC.0000000000001379

Ullrich, B., Pelzer, T., Oliveira, S., & Pfeiffer, M. (2016). Neuromuscular Responses to Short-Term Resistance Training With Traditional and Daily Undulating Periodization in Adolescent Elite Judoka. *Journal of Strength and Conditioning Research*, *30*(8), 2083–2099. https://doi.org/10.1519/JSC.0000000000001305

Ullrich, B., Pelzer, T., & Pfeiffer, M. (2017). Neuromuscular Effects to 6 Weeks of Loaded Countermovement Jumping With Traditional and Daily Undulating Periodization. *Journal of Strength and Conditioning*

Research, 1. https://doi.org/10.1519/JSC.0000000000002290

Vanezis, A., & Lees, A. (2005). A biomechanical analysis of good and poor performers of the vertical jump. *Ergonomics*, *48*(11–14), 1594–1603. https://doi.org/10.1080/00140130500101262

Vanrenterghem, J., Lees, A., & Clercq, D. De. (2008). Effect of forward trunk inclination on joint power output in vertical jumping. *Journal of Strength and Conditioning Research*, *22*(3), 708–714. https://doi.org/10.1519/JSC.0b013e3181636c6c

Wilson, G. J., Newton, R. U., Murphy, A. J., & Humphries, B. J. (1993). The optimal training load for the development of dynamic athletic performance. *Medicine and Science in Sports and Exercise*, *25*(11), 1279–1286. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8289617

Woods, K., Bishop, P., & Jones, E. (2007). Warm-Up and Stretching in the Prevention of Muscular Injury. *Sports Medicine*, *37*(12), 1089–1099. https://doi.org/10.2165/00007256-200737120-00006

Aagaard, P. (2003). Training-Induced Changes in Neural Function. *Exerc. Sport Sci. Rev*, *31*(2), 61–67. https://doi.org/10.1097/00003677-200304000-00002