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EFFECTS OF THE TRAP BAR DEADLIFT AND LEG PRESS ON ADOLESCENT MALE STRENGTH, POWER AND SPEED

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ABSTRACT

This study compared two lower body leg lifts, the trap bar deadlift (TBDL) and the leg press (LP), relative to their contributions to strength (6-RM leg strength), power (vertical jump-VJ height), and speed (36.6 meter-36.6MS) in adolescent males. Adolescent males (n=51; 13-15 years) were separated into two groups (TBDL group and LP group) via a matched pair design based on initial VJ height. Periodized resistance training was performed for 8-weeks (2x/wk) and focused on the primary exercises of the TBDL or the LP with supplemental lower body resistance training exercises (lunges, hamstring curls, calf raises, etc.) held equal between the study groups. Pre- and post-tests were conducted for 6-RM leg strength in TBDL or LP, VJ height, and 36.6MS. Both groups improved their lower body leg strength. The TBDL group improved the TBDL 6-RM by 21% (p<0.01) and the LP group improved the LP 6-RM by 19.7% (p<0.01). Despite improved strength, neither group demonstrated meaningful improvements in VJ height or 36.6MS times. The results of this study are consistent with previous literature in that lower body strength will improve when following a periodized strength training protocol in a population of adolescent males. While strength is a corner stone of power and speed, exercise protocols should include plyometrics and Olympic lift variations in order to facilitate the transfer of newly acquired strength to the attributes of power and speed. Within the parameters of this study TBDL and LP appear to be interchangeable modalities to increase lower body strength.

Keywords: *Periodized, resistance, strength, hex deadlift.*

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1. INTRODUCTION

Position stands regarding the impact of resistance training (RT) on youth suggest beneficial adaptations in bone health, body composition, motor skill development, a reduction in sport related injuries, and potentially improved psychological well-being (Behm, Faigenbaum, Falk, & Klentrou, 2008; Faigenbaum, Rhodri, & Myer, 2013; Faigenbaum, Kraemer, Blimkie, Jeffreys, Micheli, Nitka, & Rowland, 2009; Lloyd, Faigenbaum, Stone, Oliver, Jeffreys, Moody, ….., & Myer, 2014). There also appears to be promising but limited evidence that sport performance maybe enhanced as a result of RT (Behm, *et al.*, 2008). The authors of the aforementioned position stands suggest that further research is needed with regards to RT and youth in the areas of: long-term health related benefits, responsible physiological mechanisms, and the optimal RT program variables for youth (Behm, *et al.*, 2008; Faigenbaum, *et al.*, 2013; Faigenbaum, *et al.*, 2009). Where youth is broadly defined to include children and adolescents (Faigenbaum, *et al.*, 2009).

Developing a base level of muscular strength is the foundation for developing muscular power which is of particular importance for youths looking to become recreationally or competitively involved in the aforementioned sports. Exercise variations of the squat and deadlift have been used to increase strength in the lower extremities and the power zone (O’Shea, 2000). When considering modality selection for those new to RT (specifically youth), exercise selection should progress from simple to more complex movements (Faigenbaum, *et al.*, 2009).

One example of this concept might be the use of the trap bar deadlift (TBDL) which uses similar movement patterns as the back squat and may be a better choice for youth because it does not require a spotter or a safety rack (Figure 1). The back squat requires the weighted bar to be placed across the shoulders and trapezius/rhomboids which can lead to discomfort in beginners. The TBDL eliminates this potential concern. Additionally, TBDL does not require the same amount of forward trunk lean as the back squat which would likely reduce the amount of compressive and shear forces placed on the lower back. A draw back to the deadlift including the TBDL is the discomfort it causes in the hands as the participant grasps and lifts the weight bar. This could cause youths to avoid the TBDL. Since establishing RT protocols that enhance long term adherence are of importance (Faigenbaum, *et al.*, 2009), it is of interest to determine if an alternatively effective user-welcoming modality might exist.

The leg press (LP) is generally used as a supplementary exercise to the squat and dead lift. The LP can recruit different muscles than the squat and dead lift depending on the foot placement. A low foot placement on the LP does not recruit the muscles of the glutes, and hamstrings as effectively as a high foot placement (DeSilva, Brentano, Cadore, DeAlmeida, & Kruel, 2008), hence muscle group strength deficits might be addressed by utilizing the LP in a manner that the squat or deadlift variations may not be able to address. However, the LP may not be as effective as squat and dead lift because it does not require elements of trunk stability or balance. Acknowledging these differences, there is limited research with regards to the LP as a modality for increasing muscular strength as well as power.

Hence, the purpose of this study was to determine if adolescent males engaged in a RT program could use the TBDL or LP interchangeably as a modality with regards to adaptations in muscular strength, power, and speed. Exercise variations of the squat and deadlift have been used to increase strength in the lower extremities and the power zone and are consider to be superior to machine based exercise modalities (O'Shea, 2000). The TBDL is a deadlift variant and as such we hypothesized that participants utilizing the TBDL would experience the greatest improvements in the dependent variables.

2. METHODS AND MATERIALS

2.1 Participants

Participants were male students at Salem Jr. High, Utah enrolled in a body conditioning activity course. Permission was asked of all school administration and body conditioning instructors before proceeding and asking for student volunteers to participate in this study. Permission from the Institutional Review Board to use human subjects was obtained before conducting any training or assessments of the student participants. Furthermore, each participant was given a written consent form to read and sign before any action in the study was taken. Parental consent was also obtained. Each participant was required to participate in class but could choose to withdraw from the study at any time for any reason. The inclusion criteria for the study were that the participants were injury free and without a disability that would prevent participation in the training and testing protocols.

2.2 Instruments and Apparatus

All training sessions were held in the Fitness Room at Salem Jr. High School (Figure 2), Utah. Pre- and post-assessments were conducted in the same building but in a separate multi-purpose room. Equipment necessary to conduct this study included a Vertical Challenger vertical jump tester, a hand timer stopwatch for the 36.6 meter (40 yard) sprint, a leg press machine, a hexagonal dead lift bar for lower extremity strength tests and training (see Figure 1 a-d), as well as barbells and weighted plates. All of this equipment was provided by Salem Jr. High's Physical Education Department, with permission obtained from the Principal, Athletic Director, and Physical Education Teacher.

(a) **(b)** **(c)** **(d)**

Figure 1: Participant on the Hammer Strength leg press (a & b). Participant lifting the trap deadlift bar also known as the hex deadlift bar (c &d).

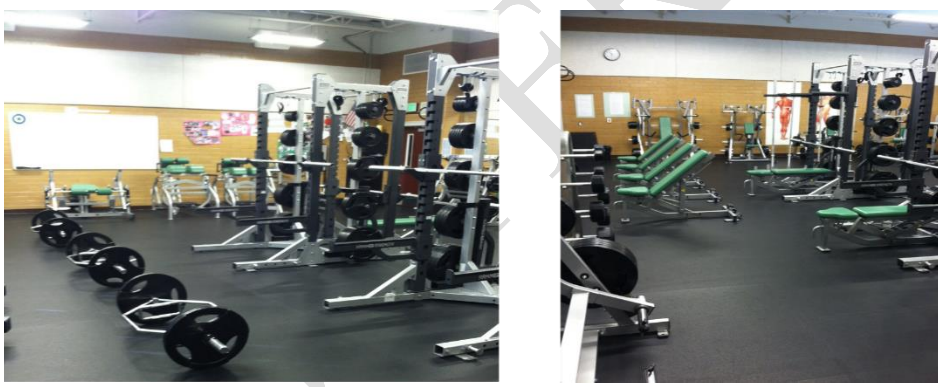

Figure 2: Salem Jr. High School training facility

2.3 Procedure

Prior to the RT intervention in this study a number of assessments were conducted over a four-day period. On day 1 the participant's height and weight were recorded. Day 2 the participant's maximum counter movement vertical jump (VJ) was recorded. For the counter movement VJ participants were allowed to continue jump attempts as long as they were hitting higher markers on the testing apparatus. When they missed two consecutive jumps their final height was recorded. No shuffling of feet or hopping into the jump was allowed. The VJ attempts were separated by approximately 2-3 minutes. The 36.6 meter sprint (36.6MS) was collected on the 3rd day of testing. After instruction on the 36.6MS the participants were allowed two sprints trials. Their times were averaged and rounded up to the nearest tenth. The participants were allowed approximately 5 minutes between sprint trials. A ten minute dynamic warmup was conducted prior to the VJ and 36.6MS testing sessions (ex. high knees jog, butt kicks, straight leg run, karaoke, knee hugs, bounding for distance, and bounding for height all over 36.6 meters).

Following the third day of testing the participants were divided into two experimental groups using a randomized matched pair design based on initial VJ test scores assuring that the groups were approximately equal with regards to leg power. The two experimental groups were the trap bar dead lift (TBDL) group and the leg press (LP) group. Once the experimental groups were established 6 repetition maximums (6-RM) were recorded. Those in the TBDL group recorded a 6-RM trap bar deadlift and the participants in the LP group recorded 6-RM leg press scores. These scores served as the pre resistance training intervention 6-RM scores for each experimental group. Also, the 6-RM scores were used to estimate 1-RMs in order to calculate training load as a percentage of the 1-RMs (Baechle, 2008).

The groups then followed their strength and conditioning program, as given by their Salem Jr. High employed physical education teacher. Both the TBDL and LP groups followed the same training protocols with exception that the TBDL group performed TBDL and the LP group performed the LP on training days.

The training sessions were done twice a week for eight weeks, totaling 16 training sessions. The eight-week training program was broken into four-two week segments where the load of the TBDL and LP was periodized as follows (sets x repetitions x %1-RM load): Weeks 1-2; 3x12x60%, Weeks 3-4; 3x8x80%, Weeks 5-6; 4x6x85%, and Weeks 7-8; 5x4x90%.

All sessions included a 10 minute dynamic warm up. After completing either the TBDL or LP students completed lunges, calf raises, and front squats. The load for each exercise was 3 sets of 10 repetitions ranging progressively from 60-90% of 1-RM over the 8 week training period. Additionally, participants performed hamstring stability ball curls and lower back extensions at 3 sets of 10 repetitions at body weight. Students followed their scheduled individual lifting prescription and recorded their training session scores on their lifting cards. An administrator was present during all training sessions to assure adherence to the training intervention period as well as reviewing the progress recorded on the lifting cards.

Following the 8-week RT period the post-intervention dependent variable measures were gathered in the same manner as described for the pre-intervention collection procedures. The principal investigator monitored all training sessions and conducted all testing sessions.

2.4 Reliability

All descriptive and dependent variables were collected as described by Baechle (2008). The test-retest reliability of short sprints has been reported to range from r=0.89-0.97 (Miller, 2012). The VJ as measured by devices such as Vertical Challenger have demonstrated a reliability coefficient of ICC=0.95 (Nuzzo, Anning, & Scharfenberg, 2011). Repetition maximums of RT exercises are commonly used to predict 1-RM measures of strength (Hoffman, 2006).

2.5 Design and Analysis

The three dependent variables in this study (i.e., VJ height, 6-RM leg exercises, and 36.6MS) were compared pre- and post-intervention RT with a paired t-test. A common gain score was also calculated for the dependent variables (post-pre) of VJ and 36.6MS. A common gain score percentage was calculated for the 6-RM strength measures ([post-pre]/pre]). The gain scores and gain score percentages were compared between experimental groups (TBDL and LP) for each dependent variable with an independent t-test. The statistical significance for this study was set at $\alpha \leq 0.05$.

3. RESULTS

There were 54 adolescent males between the ages of 12 and 15 who participated in this study and were enrolled in a HS body conditioning activity course. Three participants withdrew without explanation and did not complete the study and hence the results of this study are based on 51 participants and their demographics are reported in Table 1.

Table 1: Participant means and standard deviations for descriptive information

	N	Age (years)	Height (cms)	Mass (kgs)
LP	26	14 ± 0.6	171.5 ± 8.6	67.5 ± 13.4
TBDL	25	13.8 ± 0.7	169.2 ± 8.9	62.6 ± 13.3

Table 2: Participant Vertical Jump, 36.6 meter sprint, and 6-RM Leg Strength Descriptive Information

	VJ (cms)			36.6 Meter Sprint (seconds)			6 RM (kgs)		
	Pre	**Post**	**Gain**	**Pre**	**Post**	**Gain**	**Pre**	**Post**	**Gain%**
LP	52.9 ± 8.4	51.5 ± 8.9	-1.4 ± 3.7	6.0 ± 0.6	5.9 ± 0.5	-0.1 ± 0.4	105.7 ±31.0	127.0 ± 39.4*	21.0
TBDL	52.4 ± 8.3	52.8 ± 9.1	0.4 ± 3.5	5.7 ± 0.6	5.8 ± 0.5	0.1 ± 0.3	62.6 ±23.0	73.9 ±25.2*	19.7

*Significant improvement pre to post RT intervention $p<0.01$.

Participant dependent variable measures for both experimental groups are listed in Table 2. Neither the TBDL nor the LP groups statistically (or practically) improved in the sprint or vertical jump. The TBDL and LP groups both significantly improved from pre to post training intervention for the 6-RM measures ($p<0.01$). The TBDL and LP 6-RMs improved (pre to post) by 19.7 and 21.0% respectively. However, there was not a significant difference in gain score percentages between the TBDL and LP groups for the 6-RM measures ($p>0.05$).

4. DISCUSSION

The purpose of this study was to determine if the exercise modality of the LP or the TBDL were equally effective at enhancing muscular strength, power and speed in adolescent males engaged in a RT program. Two experimental groups were randomly assembled based on initial VJ scores. Both groups followed the same RT programs with the exception that the LP group performed the LP and the TBDL group performed the TBDL. Both groups improved 6-RM strength as a result of the RT protocols. However, there was no difference between groups with regards to strength gains. Neither experimental group improved sprint speed or VJ height. Given that the participants were relative beginners with respect to RT and given that muscular power is a product of speed and strength, we were surprised that neither group improved with regards to sprint speed or VJ ability.

The VJ scores collected in this study were reflective of 85%ile 13-14 year old boys VJ scores reported by Hoffman (2006). The 36.6MS scores recorded in this study were reflective of 30%ile 14-15year old boys 36.6MS scores (Hoffman, 2006). The average post RT LP 6-RM scores were 127.0 kgs. Based on the Brzycki (1993) 1-RM prediction equation the mean post RT LP 1-RM scores were 147.5 kg. Hoffman (2006) reported LP norms for 11-12 year old children with 105 kgs being the 90%ile. Given that the Hoffman reported norms were for a younger population inclusive of both genders it seemed reasonable that the LP scores collected in the current study would be greater. Additionally, it was not clear as to the LP used to collect the 11-12 year old norms, we suspect it was not the same LP used by the participants in this study (confounding a direct comparison). With regards to the TBDL we are unable to find normative TBDL scores reported in the literature for comparison with those documented in the current study.

The effect size (ES) for the predicted 1-RM strength gains from the LP and TPDL groups were approximately ES=0.50 which is consistent with three earlier meta-analyses regarding positive strength gains as a result of RT in youths (Behringer, Vom, Yue, & Mester, 2010; Falk, &Tenenbaum, 1996; Payne, Morrow, Johnson, & Dalton, 1997). However, VJ and sprint speed did not improve which is consistent with and in contrast to the results of prior research. Consistent with our findings, some prior studies regarding RT protocols and youth have documented significant gains in strength without accompanying improvements in motor skill performance (Faigenbaum, Milliken, Moulton, &Westcott, 2005; Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993; Flanagan, Laubach, DeMarco, Alvarze, Borchers, Dressman, & Poeppelman, 2002; Gorostiaga, Izquierdo, Iturralde, Ruesta, & Ibáñez, 1999). In contrast, numerous studies have observed enhanced motor skill performance in youth as a result of RT (Flanagan, *et al.*, 2002; Faigenbaum & Mediate, 2006; Falk, & Mor, 1996; Hetzler, DeRenne, Buxton, Ho, Chai, & Seichi, 1997; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997; Szymanski, Szymanski, Bradford, Schade, & Pascoe, 2007). It is likely that these mixed results are due to the specificity of the RT program design. As with adults, youth adapt to the specificity of the RT protocol (movement mechanics, velocity, muscle action type, and force) (Faigenbaum, *et al.*, 2009). Future studies should integrate plyometric and/or power oriented exercises such as the Olympic lifts into RT protocols with the intent of facilitating the transfer of newly acquired strength to the attributes of speed and muscular power. One form of combining RT with plyometrics is referred to as complex training (CT). CT involves performing a resistance exercise modality (ex. a back squat) followed thereafter by a biomechanically similar plyometric exercise (ex. countermovement jump). This sequence is referred to as a complex pair (Chu, 1996).

A number of researchers have documented the positive impact of CT on motor skill performance (e.g. VJ, throwing, sprinting) in youth (Ingle, Sleap, & Tolfrey, 2006; Santos, & Janeira, 2008; Roden, Lambson, & DeBeliso, 2014). The current study did not include any plyometrics, Olympic lifts or sport specific drills, which is likely why there was not an improvement in VJ or sprint times following the RT protocol intervention. With that said, youth should engage plyometric training initially with low intensity exercises (e.g. bi-lateral leg hops) and progress to more complexed and intense exercises (e.g. iso-lateral leg hops) (Behm, *et al.*, 2008; Faigenbaum, & Chu, 2014). A detailed model of a periodized

RT program that utilizes CT for high school athletes has been presented by Macaluso (2010). Likewise, Carter and Greenwood's (2014) comprehensive review and recommendations regarding CT should be a required reading for professionals and athletes whom are considering the implementation of a CT protocol.

We felt there were three primary limitations to the current study. First, while there was a common dependent variable for speed and muscular power (36.6MS and VJ) for both experimental groups in order to gage improvement, there was not so for muscular strength. Both groups used a 6-RM on the exercise modality specific to the experimental group as the dependent variable to assess muscular strength. The rationale behind doing so had to do with collecting of the post RT intervention strength scores as related to training modality specificity. The TBDL group trained with the TBDL for eight weeks. It would not be comparable to have the LP group (who did not use the TBDL over the previous 8-weeks) assess muscle strength with the TBDL. Conversely, the LP group trained with the LP for eight weeks. It would not be comparable to have the TBDL group (who did not use the LP over the previous 8-weeks) assess muscle strength with the LP. Hence, we decided to use a 6-RM to assess strength on the exercise modality that was specific to the experimental group. Secondly, attempting to compare the actual load lifted on the LP versus the TBDL is problematic. The LP used in this study was a Hammer Strength plate loaded bi lateral leg press that uses a class III lever system to provide the resistive load for the participant to overcome (which varies over the range of motion). The resistive load of the TBDL is a combination of the loaded weights and the bar (which is constant though-out the range of motion). As such, directly comparing the results of the strength gains for each group based on weight loaded of the LP or TBDL is not appropriate. However, both experimental groups reported similar lower body 6-RM strength gains (≈20%) based on the specific training modality of the experimental group. This might suggest that the LP and TBDL may be used in an interchangeable manner with in a RT protocol. For example if an individual had an injury to the hand, one could use the LP in place of the TBDL. Likewise, exercise rotation can provide a change of pace, fending off the boredom attached to lack of exercise variation. Finally, resource management is always a concern. Making sure that the LP and TBDL are always in use versus participants waiting to use either one of the implements would be an efficient use of equipment, space, and participant time. The third limitation is that both genders were not included in the current study.

In regards to overall training volume, the participants did their respective lifts (LP or TBDL) at the same intensities. However, it is difficult to tell which of the exercises put the joints, muscles and tendons under the greatest load. This is important to know because if both lifts achieve similar results most strength and conditioning professionals would want to choose the exercise that puts the least amount of stress on the body in order to attain a meaningful training effect. This is especially important for athletes in training that may spend many hours a day in practice who may be at risk of overuse injuries or experiencing training plateaus.

5. CONCLUSIONS

This study demonstrated that the TBDL and LP are both modalities that can be used for adolescents to promote muscular strength improvements in the lower body. This study underscores that RT using strength exercises alone does not necessarily transfer into speed and power. We suggest integrating explosive movements such as plyometrics and/or Olympic lift variations into RT protocols along with traditional strength exercises. Finally, the LP should be considered a viable alternative to other traditional lower body RT exercise modalities in the case of injury or for exercise rotation when the desired outcome is strength.

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