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A Preliminary Analysis of Relationships between a 1RM Hexagonal Bar Load and Peak Power with the Tactical Task of a Body Drag

by
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A critical job task for law enforcement officers that should be influenced by strength is the body drag. This study analyzed relationships between absolute and relative strength measured by a one-repetition maximum hexagonal bar deadlift (1RM HBD), with body drags completed with 74.84 kg and 90.72 kg dummies. Twenty recreationally-trained individuals completed the 1RM HBD in one session, with peak power measured via a linear position transducer. Over two subsequent sessions, participants dragged the 74.84 kg and 90.72 kg dummies with two techniques. The first technique followed Californian standards, where participants wrapped their arms around the dummy and lifted it to standing before timing commenced. In the adapted technique, timing included the initial manipulation of the dummy. Participants dragged the dummy as quickly as possible over a 9.75 m distance. Partial correlations and linear regression (controlling for sex; $p < 0.05$) analyzed relationships between the HBD and body drags. The standard 74.84 kg body drag correlated with every HBD variable ($r = -0.477$ to -0.666), and was predicted by the absolute 1RM HBD ($r^2 = 0.467$). The adapted 74.84 kg drag correlated with all HBD variables ($r = -0.535$ to -0.754), and was predicted by peak power and the 1RM HBD ($r^2 = 0.758$). Both 90.72 kg drags correlated with absolute and relative 1RM HBD ($r = -0.517$ to -0.670). Strength related to all body drags; peak power may be more important for drags with lighter loads. Strength training should be a focus in law enforcement to enhance drag performance.

***Key words**: casualty drag, lower-body strength, police, tactical athlete, victim drag.*

Introduction

Tactical populations (e.g. law enforcement, firefighters, and military) may be required to complete physically demanding tasks when they are on-duty or during deployment. One task that is common to all of these populations and tactical athletes in general is the body drag, which has also been referred to as a victim or casualty drag. In this task, a law enforcement officer (LEO) (Lockie et al., 2018b, 2019; Moreno et al., 2019), a firefighter (Sheaff et al., 2010; Williams-Bell et al., 2009), or a soldier (Foulis et al., 2017; Mala et al., 2015) must rapidly drag an incapacitated civilian or colleague from a hazardous environment to a safe location. Given the life-saving implications of a task such as the body drag, it is often incorporated into job-specific testing for tactical populations to ascertain physical readiness for the job. Examples of this include the Candidate Physical Ability Test (CPAT) for firefighters in the USA (Sheaff et al., 2010; Williams-Bell et al., 2009), and the Work Sample Test Battery (WSTB) for Californian LEOs (Lockie et al., 2018b, 2019).

What can vary in a simulated body drag across these tactical populations is the load, dragging distance, and a method required for the drag. In the CPAT, firefighter candidates must drag a 74.84 kg (165 lb) dummy by shoulder harnesses 10.7 m, before completing a 180° turn and returning along the 10.7 m distance back to

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the starting point (Williams-Bell et al., 2009). In a job simulation analysis, US Army soldiers were required to drag a 123 kg dummy 15 m in 30 s (Foulis et al., 2017). Specific to law enforcement in the state of California in the USA, recruits must complete a body drag with a 74.84 kg dummy over a distance of 9.75 m before they can graduate from academy (Lockie et al., 2018b, 2019; Moreno et al., 2019). The body drag must be completed within 28 s for a recruit to attain points for the WSTB (Lockie et al., 2019).

A novel aspect of the body drag in the WSTB is that recruits must wrap their arms around the chest of the dummy and lift it to a standing position before they commence the drag. Given that this is essentially an adapted deadlift, this would suggest that absolute strength would contribute to this task. The potential value of strength takes on greater import when considering the current format of the body drag may not be reflective of the current USA population. The average adult female in the USA weighs approximately 75 kg, while the average male is approximately 90 kg (Fryar et al., 2016). Furthermore, if a LEO is required to drag one of their colleagues, their colleague may be carrying approximately 8-22 kg of equipment depending on their job duties, which is supplemental to their body mass (Baran et al., 2018; Joseph et al., 2018). It could be assumed that if a LEO must drag a greater load, whether it is due to a heavier civilian or a colleague loaded with their equipment, they would need greater strength.

Military populations have recognized the importance of lower-body strength to lifting tasks. For example, lower-body strength measured by a back squat was found to correlate with the time to drag a 79.5 kg dummy 10 m in Army Reserve Officer Training Corps and civilian university students (Mala et al., 2015). The US Army has also recently incorporated the hexagonal bar deadlift (HBD) as a physical ability test for potential soldiers (Military Performance Division, 2015). Despite the potential validity of the HBD as an indicator of dummy drag ability for recruits and LEOs, this test is not common in law enforcement populations. Indeed, after finding significant relationships between lower-body power measured by the vertical and standing broad jump with body drag velocity in Californian law enforcement recruits, Moreno et al. (2019) recommended using the HBD to measure strength in this population.

The significant relationships between lower-body power and the body drag are notable (Moreno et al., 2019), especially within the context of strength and the expression of force. What can be important is not just how much load is lifted in a strength-based task, but how fast that load is lifted (Lockie et al., 2017). This relates to the power generated in the task. Several studies have measured peak power within the HBD (Lockie et al., 2018d, 2018e). It would be of interest not just to determine whether the load lifted in the HBD relates to the tactical task of a body drag, but whether the peak power generated from the HBD relates as well. Given the urgency of the body drag if it needs to be performed by a LEO when on duty, it may be expected that peak power is important. This information could be used to drive training practices for law enforcement recruits.

Therefore, the purpose of this study was to identify relationships between the one-repetition maximum (1RM) HBD with a body drag completed with a 74.84 kg and a 90.72 kg (200 lb) dummy in recreationally-trained men and women. Peak power in the HBD was measured with a linear position transducer (Lockie et al., 2018d, 2018e). The procedures required for the WSTB body drag were adopted in this study for the two dummy loads (Lockie et al., 2018b, 2019; Moreno et al., 2019), in addition to an adapted method that will be described. It was hypothesized that there would be significant relationships between the absolute and relative load, in addition to peak power, from the 1RM HBD with body drags with both the 74.84 kg and 90.72 kg loads.

Methods

Participants

A convenience sample of 20 participants (age = 24.50 ± 3.82 years; body height = 1.74 ± 0.11 m; body mass = 75.31 ± 14.30 kg), including 11 males (age = 25.18 ± 4.98 years; body height = 1.81 ± 0.11 m; body mass = 83.24 ± 13.31 kg) and 9 females (age = 23.67 ± 1.50 years; body height = 1.67 ± 0.04 m; body mass = 65.62 ± 8.52 kg) volunteered to take part in this study. Participants were recruited from the student population at the university via information sessions on campus and word-of-mouth amongst the students. Similar to previous research, physically active and healthy volunteers were used as surrogates for a tactical population (Mala et al., 2015; Stevenson et al., 2017; Williams-Bell et al., 2009). The recruitment of civilians allowed for similar proportions of males and females with divergent physical abilities (Stevenson et al., 2017). G*Power software (v3.1.9.2, Universität Kiel, Germany) confirmed post hoc that the sample size of 20 was sufficient for a correlation, point biserial model, and ensured the data could be interpreted with a moderate effect level of 0.50 (Hopkins, 2004), and a power level of 0.80 when significance was set at 0.05 (Faul et al., 2007). Participants were required to be free from any musculoskeletal disorders that could influence study participation. The California State University, Fullerton review board approved the study (HSR-18-19-109), all participants received a clear explanation of the procedures (including potential risks and benefits of participation), and written informed consent was obtained. The study also conformed to the recommendations of the Declaration of Helsinki.

Procedures

Three testing sessions was used per participant, separated by 48-72 hours depending on participant availability. On day one, the participant signed the informed consent form and had their age, body height, and mass recorded. Body height was measured barefoot using a portable stadiometer (Detecto, Webb City, MO, USA), while body mass was recorded by electronic digital scales (Ohaus, Parsippany, NJ, USA). Following this, participants completed a standard dynamic warm-up, which was also used on days 2 and 3. The participants cycled for 5 minutes at a self-selected intensity on a bicycle ergometer, before completing approximately 10 minutes of upper- and lower-body dynamic stretching. After the warm-up, participants completed their 1RM HBD following procedures that will be detailed. Familiarization to the body drag was also completed on day 1, such that participants achieved the required body drag techniques for the subsequent testing sessions. Participants completed several practice drags as required with both dummies. On days 2 and 3, participants completed body drags with either a 74.84 kg or a 90.72 kg dummy. Which dummy was used on each testing day was counterbalanced amongst the sample; half the participants dragged the 74.84 kg dummy on day 2 and the 90.72 kg dummy on day 3, while the other half did the opposite. Participants refrained from intensive lower-body exercise and maintained a standardized dietary intake in the 24-hour period prior to each testing session, and were permitted to consume water as necessary throughout each testing session.

The 1RM HBD

The 1RM HBD was performed as previously described in the literature (Lockie et al., 2018d, 2018e). The HBD was performed with a dual height hexagonal bar (American Barbell, San Diego, CA), where the distance between the center of the low and high handles was 0.10 m, and the distance between the centers of the two high handles was 0.64 m. The high handles were used in this study (Lockie et al., 2018d, 2018e; Military Performance Division, 2015). Following the standard warm-up, participants completed four specific warm-up sets, with 3 min rest intervals between each set. These sets were composed of 10 repetitions at 50% of estimated 1RM by the participant, followed by 5 repetitions at 70% of 1RM, 3 repetitions at 85% 1RM, and 1 repetition at 90% 1RM. After the warm-up sets, the weight was increased by approximately 5% and participants completed a single repetition. This process continued until the participant was unable to complete a repetition, with 3 min rest intervals provided between successive attempts. Participants were instructed to lift the bar with as much force as possible, and a successful repetition was attained when the participant was standing erect within the frame of the hexagonal bar by extending the knees and retracting the shoulders, which was determined by an investigator positioned adjacent to the participant (Lockie et al., 2018d, 2018e). If the participant did not attain this position, or if the bar was lowered at any point during the ascent, the lift was deemed unsuccessful. No more than five attempts were required before the 1RM was attained. In addition to the absolute load, the 1RM was also calculated relative to body mass according to the formula: *relative 1RM* $(kg \cdot BM^{-1}) = 1RM \cdot body\ mass^{-1}$.

Peak power measured in watts from the 1RM HBD was recorded by a GymAware Powertool linear position transducer (Kinetic Performance Technology, Canberra, Australia), with the cable attached to the front of the hexagonal bar. The unit was then placed on the floor directly underneath the attachment point, with the magnetic bottom positioned on top of a weight plate to ensure it did not move. The encoder recorded velocity and the movement of the bar at 50 Hertz for every 3 millimeters of bar movement. Peak power for each 1RM attempt, derived relative to the load on the bar, was recorded on an iPad handheld device (Apple Inc., Cupertino, California).

The Body Drags

Body drag testing was conducted over two sessions, and as stated, which dummy mass was dragged in the first session was counterbalanced amongst the sample. All body drag trials were performed on a polished wooden floor, with adhesive tape marking the start and finish lines for the 9.75 m dragging distance. The dummies were always positioned face side up, with the head orientated towards the finish line, and the feet 0.3 m behind the starting line. Two dragging methods were used for each dummy, and were performed in this order. The standard drag followed established procedures for Californian LEOs (Lockie et al., 2018b, 2019; Moreno et al., 2019). Participants were required to pick up the dummy by wrapping their arms underneath the arms of the dummy and lifting it to a standing position by extending the hips and knees. Once standing with the dummy, the participant informed the tester they were ready, and timing was initiated when the feet of the dummy passed the start line. The second method was referred to as the adapted drag. Participants were instructed to grip the dummy in whatever manner they preferred (i.e. they did not have to pick up and stand with the dummy; they could just drag it from the ground). However, participants could not grab the head or legs, or attempt to lift the dummy over their shoulders; it had to be some form of the drag. For these trials, participants were positioned behind the dummy, and the researcher gave a 3 s countdown. Participants were to grip the dummy and commence dragging as soon as the countdown finished and the researcher stated "Go!", which was when timing commenced. As a result, how the participant initially manipulated the dummy was included within the time.

In all trials, participants dragged the dummy as quickly as possible by walking backwards over the required distance. Timing stopped when the dummy's feet crossed the finish line, and was recorded to the nearest tenth of a second. Time was recorded via a stopwatch by a researcher trained in the use of stopwatch procedures (Lockie et al., 2018b, 2019; Moreno et al., 2019). Testers trained in the use of stopwatch timing procedures for fitness tests can record reliable data (Hetzler et al., 2008). Two trials were completed for the standard drag, and two trials for the adapted drag (four drag trials in total for each session), with 3 min rest intervals between trials.

Statistical Analysis

All statistical analyses were computed using the Statistics Package for Social Sciences (Version 25.0; IBM Corporation, New York, USA). Descriptive statistics (mean ± standard deviation [SD]) were calculated for each variable. To confirm the need to control for sex in the analyses, independent samples t-tests were used to compare the male and female groups, with significance set at $p < 0.05$. Effect sizes (Cohen's d) for the between-sex comparisons were also calculated from the difference between the means divided by the pooled standard deviations (Cohen, 1988). A d less than 0.2 was considered a trivial effect; 0.2 to 0.6 a small effect; 0.6 to 1.2 a moderate effect; 1.2 to 2.0 a large effect; 2.0 to 4.0 a very large effect; and 4.0 and above an extremely large effect (Hopkins, 2004).

Partial correlations controlling for sex were used to determine relationships between the body drag tests and absolute and relative strength measured from the HBD, in addition to peak power ($p < 0.05$). Partial correlations were used because numerous studies have documented sex differences in the physical performance of law enforcement-related tasks (Dawes et al., 2017b; Lockie et al., 2018c, in press). The correlation strength was designated as: an r between 0 to ±0.3 was considered small; ±0.31 to ±0.49, moderate; ±0.5 to ±0.69, large; ±0.7 to ±0.89, very large; and ±0.9 to ±1, near perfect for relationship prediction (Hopkins, 2002). Stepwise linear regression analyses ($p < 0.05$), with sex as a control variable, were conducted for each drag to illustrate whether absolute 1RM HBD, relative 1RM HBD, or peak power predicted standard or adapted drag performance for the 74.84 kg or 90.72 kg dummies. This approach was undertaken due to the exploratory nature of this research (Lockie et al., 2018b).

Results

Descriptive data are shown in Table 1. There were significant differences between the sexes for four of the seven variables, and effects ranged from small (relative 1RM HBD) to large (1RM HBD). These data confirmed the need to use sex as a control variable for the correlations and linear regression. The correlation data are shown in Table 2. All significant relationships indicated greater strength or power related to a faster drag time. The standard 74.84 kg body drag had significant, negative relationships with every HBD variable. Absolute and relative 1RM HBD correlations were large, while the peak power correlation was moderate. The adapted 74.84 kg body drag also had significant, negative relationships with all HBD variables. There was a large correlation with the relative 1RM HBD, and very large correlations with absolute 1RM HBD and peak power. Both 90.72 kg body drags significantly correlated with absolute and relative 1RM HBD (all large relationships), but not with peak power.

The stepwise linear regression data are shown in Table 3. The standard 74.84 kg body drag was predicted by absolute 1RM HBD, with an explained variance of 46.7%. The adapted 74.84 kg body drag was predicted by peak power and absolute 1RM HBD (explained variance = 75.8%). The standard and adapted 90.72 kg body drag was not predicted by the HBD in this study when sex was included as a control variable.

Table 1

Descriptive data (mean ± SD) for all participants, males and females, in the 1RM HBD (absolute and relative load, peak power) and the standard and adapted 74.84 kg and 90.72 kg body drags.

	All (N = 20)	Males (n = 11)	Females (n = 9)	*p*	*d*
1RM HBD (kg)	137.73 ± 40.65	160.46 ± 38.43	109.94 ± 22.35*	0.003	1.61
Relative 1RM HBD ($kg \cdot BM^{-1}$)	1.83 ± 0.45	1.95 ± 0.49	1.70 ± 0.38	0.230	0.57
Peak Power (watts)	864.80 ± 338.12	1017.73 ± 357.97	677.89 ± 199.71*	0.021	1.17
Standard 74.84 kg Body Drag (s)	6.46 ± 1.90	5.71 ± 1.64	7.38 ± 1.87*	0.048	0.95
Adapted 74.84 kg Body Drag (s)	7.56 ± 1.69	6.80 ± 1.43	8.50 ± 1.56*	0.020	1.14
Standard 90.72 kg Body Drag (s)	7.85 ± 3.10	6.78 ± 2.84	9.05 ± 3.08	0.113	0.77
Adapted 90.72 kg Body Drag (s)	9.27 ± 3.89	7.80 ± 2.08	11.06 ± 4.89	0.060	0.87

** Significantly ($p < 0.05$) different from males.*

Table 2

Correlations between the standard and adapted 74.84 kg and 90.72 kg body drag with the 1RM HBD (absolute and relative load, peak power).

		Standard 74.84 kg Body Drag	Adapted 74.84 kg Body Drag	Standard 90.72 kg Body Drag	Adapted 90.72 kg Body Drag
1RM HBD	*r*	-0.666*	-0.754*	-0.670*	-0.557*
	p	0.003	<0.001	0.002	0.016
Relative 1RM HBD	*r*	-0.619*	-0.535*	-0.528*	-0.517*
	p	0.006	0.022	0.024	0.028
Peak Power	*r*	-0.477*	-0.727*	-0.350	-0.409
	p	0.045	0.001	0.155	0.092

** Significant ($p < 0.05$) difference between the two variables.*

Table 3

Stepwise linear regression analysis between the standard and adapted 74.84 kg body drag (N = 20).

Variables	*r*	r^2	Significance
Standard 74.84 kg Body Drag			
Absolute 1RM HBD	0.683	0.467	0.005
Adapted 74.84 kg Body Drag			
Peak Power	0.814	0.662	<0.001
Absolute 1RM HBD	0.871	0.758	<0.001

NOTE: Sex was used as a control variable so was involved in all significant relationships; only those HBD variables that predicted body drag performance are noted here.

Discussion

This study provided a preliminary analysis of the relationships between 1RM HBD performance and the 74.84 kg and 90.72 kg body drags. In addition to the absolute and relative loads from the 1RM HBD, peak power was also measured and correlated with the body drags. Even though participants in this study were not law enforcement recruits or officers, previous research has also used civilians in lieu of tactical personnel or athletes, with the expectation that physical qualities important for tactical tasks would be consistent across males and females from similar population demographics (Mala et al., 2015; Stevenson et al., 2017; Williams-Bell et al., 2009). Furthermore, law enforcement agencies do recruit from the general population. The results indicated that absolute and relative strength correlated with both the 74.84 kg and 90.72 kg body drags; peak power only correlated with the 74.84 kg drag. Specific to a tactical task such as a body drag, this exploratory analysis provides useful information that could influence physical training in tactical populations such as law enforcement recruits.

The standard 74.84 kg body drag is a component part of the WSTB for LEOs, and must be completed before a recruit can graduate academy (Lockie et al., 2018b, 2019; Moreno et al., 2019). Additionally, this dummy mass is closely matched to data from the average adult female in the USA (Fryar et al., 2016). This preliminary study is the first to show that maximal strength (both absolute and relative 1RM HBD, and IRM HBD peak power) related to the tactical task of the WSTB body drag performed by recreationally trained males and females. Additionally, with sex as a control variable, the standard 74.84 kg body drag time was predicted by the absolute 1RM HBD. Although lower-body power measured via jump tests has been correlated with the 74.84 kg body drag in law enforcement recruits (Moreno et al., 2019), lower-body strength has not been until this exploratory analysis. This is important, especially as maximal strength testing or training is not often a focus of training for LEOs (Lockie et al., 2018b, 2019). Muscular endurance and aerobic fitness are often more of a focus, and physical tests related to these capacities (e.g. push-ups and sit-ups for muscular endurance, distance runs such as a 2.4 km run for aerobic fitness) did not relate to a standard 74.84 kg body drag in law enforcement recruits (Lockie et al., 2018b). Although further investigation is required, these initial results suggest the potential value of utilizing more maximal strength training for law enforcement populations, as it could assist performance in a task such as a 74.84 kg body drag.

Performance in the 1RM HBD also correlated with the adapted 74.84 kg body drag. What is interesting to note is that the correlations for absolute 1RM HBD and peak power were stronger for the adapted 74.84 kg body drag (both very large) than the standard drag (large and moderate, respectively). Further to this, the adapted 74.84 kg body drag time was predicted by absolute 1RM HBD and peak power, with 76.8% explained variance. In contrast to the standard drag, the adapted drag included the initial manipulation of the dummy. That is, in the standard drag, time is not started until they are already standing with the dummy. As a result, any physical qualities that could be important to the initial grasping and lifting of the dummy may not have as much impact in the standard 74.84 kg body drag. It could be expected that absolute strength is important in lifting the 74.84 kg dummy from the ground, and given the urgency of the task (i.e. the drag must be completed as quickly as possible), this could also be influenced by the generation of peak power during the lift. Greater peak power could relate to a higher muscle contraction velocity (Blatnik et al., 2014), which would clearly be beneficial if a LEO needs to drag a civilian or a colleague from a hazardous environment.

The 90.72 kg dummy was utilized in this preliminary analysis as it closely matches the current USA population data for the average male (Fryar et al., 2016). As could be expected, absolute and relative 1RM HBD correlated with both the standard and the adapted 90.72 kg body drag. Interestingly, peak power did not correlate with either drag with the 90.72 kg dummy. The heavier mass clearly increased the challenge associated with the task, given the increase in time required to drag the dummy the 9.75-m distance. Peak power within strength-based tasks, such as in the back squat (Zink et al., 2006), deadlift (Blatnik et al., 2014), or bench press (Lockie et al., 2018a), is generally not optimized at heavier loads. This is partially due to an increase in time needed to generate the high degree of force required to overcome the inertia of the heavier load, leading to a decreased muscle contraction velocity (Blatnik et al., 2014). Accordingly, if a LEO, or some other tactical operator or athlete (e.g. firefighter or soldier) needs to drag a heavier civilian or colleague loaded with specific equipment, maximal strength could be an essential physical quality. These preliminary findings are very notable, given that law enforcement training academies often focus more on body weight calisthenics and aerobic conditioning (Lockie et al., 2018b, 2019), as opposed to maximal strength training. The current results suggest that maximal strength training should be emphasized more considering the specific tactical task of a body drag, especially if heavier loads need to be dragged when on duty.

There are some study limitations that should be acknowledged. This study did not use law enforcement recruits, although as stated, this approach has been adopted in other studies (Mala et al., 2015; Stevenson et al., 2017; Williams-Bell et al., 2009). This is because the physical qualities important for a tactical task should be similar whether they are performed by a tactical operator or recruit, or a civilian (Stevenson et al., 2017). The sample size was relatively small (N = 20), although this still provided an initial analysis of the potential influence of strength on an essential task for tactical populations. Nonetheless, larger sample sizes should be used in forthcoming studies analyzing strength and the body drag. Research should also combine lower-body strength measured by a test such as the HBD, and lower-body jump tests as additional measures of power. This is appropriate, as jump performance has been related to the 74.84 kg body drag (Moreno et al., 2019). Further to this, jump testing has been used in law enforcement (Dawes et al., 2017a; Lockie et al., 2018c), firefighter (Peterson et al., 2008), and military (Harman et al., 2008; Knapik et al., 2001) populations. Future research should also investigate whether maximal strength training can positively influence how a law enforcement recruit performs a body drag at the end of academy training.

In conclusion, this preliminary study showed that greater absolute and relative strength as measured by the 1RM HBD related to faster performance in both the 74.84 kg and 90.72 kg body drags in recreationally-trained males and females. Peak power only related to the 74.84 drag; this could be because the lighter load involved faster muscle contraction velocities (Blatnik et al., 2014), allowing for a potentially greater expression of peak power. In contrast, for the 90.72 kg body drag, absolute strength may take on greater importance in order to overcome the inertia of the heavier mass. These exploratory data suggest that maximal strength training could be valuable for law enforcement (and other tactical) populations, especially as it relates to performance of the body drag. Future research should investigate how lower-body strength and power measured via jump tests could relate to body drag performance, in addition to whether specific strength training does enhance performance of this job-specific task.

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