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Original Research

Lower-body Power and its Relationship with Body Drag Velocity in Law Enforcement Recruits

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ABSTRACT

International Journal of Exercise Science 12(4): 847-858, 2019. The body drag (BD) is used as a test to measure a law enforcement officer (LEO) recruit's capability to rescue an individual. However, the physical characteristics associated with faster BD performance have not been identified. It could be expected that lower- body power, often measured via jump performance, could positively relate to BD performance. This study investigated the relationship between the vertical jump (VJ), peak anaerobic power measured in watts (PAPw), power-to-body mass ratio (P:BM), standing broad jump (SBJ), and relative SBJ, with BD velocity in LEO recruits. Retrospective analysis of data from 94 (male=71, female=23) recruits from one law enforcement agency were used. PAPw and P:BM ratio were derived from VJ, and relative SBJ from SBJ distance. The BD involved dragging a 75- kg dummy backwards 9.75 m, with velocity derived from distance traveled over time. Pearson's correlations ($p \leq 0.05$) calculated the relationship between variables and BD velocity. A stepwise linear regression determined predictive relationships between the jump variables and BD velocity. BD velocity demonstrated a small significant relationship with the VJ (r=.209), a large significant relationship with PAPw (r=.568), and a moderate significant relationship with P:BM (r=.489). Large and moderate significant relationships with SBJ (r=.609) and relative SBJ (r=.426) were also identified. The regression model of sex, SBJ, and PAPw explained 67% of the variance. Horizontal power, and power generated relative to body mass, contribute to a faster BD. This suggests that recruits should add complete power exercises such as SBJ and VJ to their training to prepare for this task.

KEY WORDS: Victim rescue, occupational testing, police, tactical strength and conditioning

INTRODUCTION

First responders, which can refer to emergency medical services, firefighters, and law enforcement officers (LEOs), are responsible for ensuring public safety through rapid deployment to the scene of an emergency. Although different first responder professions have varying occupational tasks (1, 4, 10, 16, 20, 22, 23), a common thread linking them together is that during an emergency they may be required to rescue someone from immediate danger. This could include physically dragging an individual from a hazardous environment to a position of safety. Indeed, the rescuing of another human being may be one of the most fundamental job tasks of any first responder profession. Furthermore, research into first responders has identified dragging as a critical and commonly encountered job task for these populations (4-6, 17, 20, 22).

Accordingly, first responder agencies typically utilize physical testing to screen recruits for their potential to successfully rescue an individual (4, 7, 23, 29, 35, 42). For example, within the state of California, the Peace Officers Standard and Training organization administers an exit physical assessment exam for LEOs, which is called the Work Sample Test Battery (WSTB) (23). The BD is one of five tests, and to successfully complete this event, the recruit must drag a 75-kg dummy 9.75 meters (m) in 28 seconds or less in a backwards motion (39). There are many considerations that must be addressed by a law enforcement agency (LEA) when screening their candidates for this job task. First is the mass of the dummy relative to the population. Striking a balance between being representative of the weight of the current population while also not disparately impacting recruits is a challenge. According to recent data, the average adult male and female in the USA have gotten heavier (18), with the average adult male over 20 weighing approximately 88.8 kg. Interestingly, the 75-kg dummy used for California LEAs is comparable to population data from the 1960s (43). Likewise, a degree of control over testing conditions is required to ensure maximum validity and reliability, and as such, testing conditions may not always accurately reflect real world rescuing conditions. For example, the dummy in the WSTB event starts sitting in an upright position and must be dragged backwards in a straight line using a standardized grip (39). Officers finding themselves performing this task in the field may be required to use other grips, use drag handles built into officer's vests, or drag the victim longer distances around obstacles or on uneven terrain, due to the dynamic nature of these events.

One of the goals of academy period for LEAs is to physically train recruits so they possess the qualities required to pass the WSTB, including the BD, and graduate academy. However, there is limited information regarding the physical characteristics required to successfully perform the BD in a law enforcement population. This is exacerbated by the typical assessments used to characterize fitness in law enforcement and first responder populations, which tend to have a focus on strength endurance (e.g. push-ups and sit-ups) and aerobic fitness (e.g. 2.4-km run and multistage fitness test) (9, 12, 14, 15, 23, 24, 38). Lockie et al. (23) examined the relationships between commonly used law enforcement fitness tests and the BD and found there was no significant correlations between the tests utilized (push-ups, sit-ups, mountain climbers, pull-ups, 201-m run, and 2.4-km run) and the BD. Previous research has indicated that anaerobic characteristics, including power, might be important to successfully complete law enforcement job tasks (13, 23), and this is possibly true for the BD. However, there has been limited analysis of this specific job task in first responder populations.

There has been some analysis of BD or victim drag tasks in military populations. The United States Army recently updated its own occupational test to become more relevant to today's soldiering tasks (6, 17, 35). In this update, a standing broad jump and hexagonal bar deadlift with a 100-kg load were utilized to assess lower-body power and strength, which have been linked to soldiering tasks such as a casualty rescue (35). However, the military BD involves a dummy that weighs 123 kg, in contrast to the 75-kg dummy used in the state of California for law enforcement recruits. This added weight is due to the average solider wearing and carrying loads which can increase their total mass to approximately 123 kg (6, 17). For the military BD, the dummy must be dragged 15 m in under 30s (17). While the heavier load may place additional importance on maximal lower-body strength, the focus of the test is still the ability to complete it in the shortest time possible (17), which means that speed of movement and power are important to the successful completion of the task. Despite the occupational differences between the law enforcement and the military BD, the changes to the military testing, combined with the results from Lockie et al. (23), suggest that examining lower-body power as it relates to the BD is required.

Therefore, the purpose of this study was to examine how lower-body power relates to performance on a BD task in a law enforcement population. A retrospective analysis was conducted on fitness test data gathered from LEA recruits in the week prior to academy. The LEA training staff administered a vertical jump (VJ), standing broad jump (SBJ), and the BD test. Peak anaerobic power measured in watts (PAPw) and power-to-body mass ratio (P:BM) was calculated from the VJ (41), while SBJ distance was also made relative to body mass (26). It was hypothesized that there would be a significant positive relationship between measures of lower-body power and BD velocity, in that recruits that were more powerful would be able to perform the BD faster.

METHODS

Participants
Data were collected by the staff from one US-based LEA in the week preceding academy training and was released for data analysis with consent from that organization. This sample of convenience was composed of 94 recruits (age: 27.38 ± 7.01 years; height: 1.72 ± 0.09 m; body mass: 78.5 ± 12.9 kg) of which there were 71 males (age: 27.62 ± 7.78 years, height: 1.75 ± 0.07 m, body mass: 83.22 ± 10.57 kg) and 23 females (age: 26.65 ± 3.84 years, height: 1.60 ± 0.05 m, body mass: 63.94 ± 7.72 kg). The sample incorporated one LEA training cohort that started their academy in the Fall in southern California. Any strength and conditioning programs prior to academy were generally completed voluntarily at the individual-level only by recruits (25, 31). Based on the archival nature of this analysis, the institutional ethics committee approved the use of pre-existing data. Nonetheless, the study still conformed to the recommendations of the Declaration of Helsinki.

Procedures
The data utilized in this study was gathered by a local LEA training staff using the procedures detailed herein. The staff were all trained by the LEA, and all staff were verified as proficient by a certified Tactical Strength and Conditioning Facilitator. Prior to testing, each recruit's age, height, and body mass were recorded. Height was measured barefoot using a portable

stadiometer (Seca, Hamburg, Germany), while body mass was recorded by electronic digital scales (Health o Meter, Neosho, Missouri). All testing was done one week prior to the start of their academy. Recruits wore physical training attire and not their uniforms or duty loads. Testing occurred in the morning between 0600-0800 and occurred outdoors on concrete at the LEA's training facility. Temperatures and conditions were consistent with California weather during this time of the year. Although testing outdoors is not ideal, there was no indoor testing facility available for this LEA and these procedures were typical of staff from the LEA (23). Recruits rotated through the tests in groups of 8-10 and were permitted to consume water as required during testing.

Vertical Jump (VJ): A Vertec measurement tool (Perform Better, Rhode Island, USA) was utilized to measure VJ height and followed established protocols (2, 9). To measure VJ height, the recruit initially started side-on with the Vertec on the recruits' dominant side. Then, the recruit was instructed to extend the dominant arm as high as they could reach to displace as many of the vanes as possible while keeping their heels on the floor. The last vane moved became the zero-reference point. After adjusting the Vertec to accommodate the reference point, the recruit was then instructed to jump as high as possible with no preparatory step. The recruit was instructed to perform a countermovement jump, but no restrictions were placed on the depth of the countermovement. VJ height was calculated by subtracting the initial standing reach height from the maximal jump height. Each recruit completed two trials with two minutes rest between each, with the best trial being used for statistical analysis. PAPw was calculated from this trial using the equation from Sayers et al. (41): Peak Power (watts; w) = $(60.7 \cdot \text{VJ height [cm]}) + (45.3 \cdot \text{body mass [kg]}) - 2055$. The resulting PAPw variable was then calculated relative to the body mass of each recruit (P:BM) (26).

Standing Broad Jump (SBJ): The protocol used to measure SBJ distance was adapted from previous research (21, 26). SBJ trials occurred alongside a tape measure fixed to the ground with adhesive tape. Each recruit started with their toes on a marked piece of adhesive tape level with 0 cm. Following a simultaneous arm swing and crouch, the recruit performed a maximal forward leap making sure to land with both feet. Using a dowel to make a straight line from the rear heel to the measuring tape, the distance from the rearmost heel to the start line was measured as the SBJ distance to the nearest centimeter. The best of two trials was taken as the recruit's final score. If the recruit took an additional step, or failed to maintain balance, the recruit was allowed an additional jump attempt and the previous score was discarded. Relative SBJ was calculated by diving the SBJ distance against the body mass of each recruit (26).

Body Drag (BD): The protocol for the BD test was detailed in this particular agency's proctor guide for the WSTB (39). Adhesive tape was used to mark the start and finish lines for the 9.75-m dragging distance. The dummy was positioned face side up, with the head orientated towards the finish line. The feet were positioned 30.48 cm behind the starting line. The recruit started by squatting and placing their arms under the dummy's arms and across the chest. The recruit was not allowed to grip or pull on any other part of the dummy, such as by pulling the arms or the head, as they then lifted the dummy off the floor and into the starting position. Times were recorded by the training staff and did not begin until the dummy's feet had crossed the start line. The time stopped when the dummy's feet crossed the finish line, and time was recorded to the nearest tenth of a second. A spotter was present as a safety precaution and was behind the recruit as they completed the test. A single trial was completed; this was due to time constraints, but also followed the procedures for the WSTB (23, 39). Velocity (m·s-1) was calculated by dividing the recruits drag time by the length of the test (9.75 m) (17).

Statistical Analysis

Statistical analyses were processed using the Statistics Package for Social Sciences (Version 25; IBM corporation, New York, USA). Data were combined for male and female recruits, and partial correlations controlling for sex were ran to calculate relationships between the power variables and BD velocity. An alpha level of $p < 0.05$ was required for significance. Previous research has combined sex data for analyses in law enforcement populations (24, 32). Nonetheless, partial correlations were chosen for this study due to other research documenting sex differences in fitness test performance for law enforcement populations (14, 25, 30). The correlation strength were designated as follows: an r value between .0 and ±0.3 was considered small; ±.31 to .49 was moderate; ±.50 to ±.69 was large; ±.79 to ±.89 was very large; and ±.9 to ±1 was near perfect (19). A stepwise linear regression controlling for sex was performed to determine whether any power variable predicted DD velocity ($p < 0.05$). This approach was undertaken due to the exploratory nature of this study (23).

RESULTS

Table 1 displays the descriptive statistics for the power tests and BD. Table 2 displays the correlation data between the BD and all other variables. There was a significant small, negative correlation between age and BD velocity, but no significant correlations with height or body mass. Considering the indirect measures of lower-body power, there was a significant small positive correlation between VJ and BD velocity, and a significant large positive correlation between SBJ distance and BD velocity. Regarding the relative measures of power, two significant moderate positive correlations existed; relative SBJ and BD velocity, as well as P:BM ratio and BD velocity. Furthermore, a significant large positive correlation between PAPw and BD velocity was identified.

Table 3 details the stepwise linear regression data. Sex was used as a control variable. SBJ was a significant predictor of BD velocity, and combined with sex explained 63% of the variance. When PAPw was added to the linear regression, 67% of the variance was explained.

Table 1. Descriptive data for the performance on the body drag, vertical jump, peak power measured in watts, power: Body mass ratio, standing broad jump, and relative SBJ in law enforcement recruits (n=94).

Variable	Mean ± SD
Body Drag Velocity (m ·s-1)	5.04 ± 1.27
Vertical Jump (cm)	48.9 ± 28.46
Peak Power (w)	4633.47 ± 1060.81
Power:Body Mass Ratio (w ·kg-1)	58.88 ± 9.21
Standing Broad Jump (cm)	179.19 ± 42.91
Relative Standing Broad Jump (cm ·kg-1)	2.30 ± 0.57

Table 2. Partial correlations (controlling for sex) between the body drag velocity (BD velocity), vertical jump, peak anaerobic power measured in watts (PAPw), power:body mass ratio (P:BM) standing broad jump (SBJ), and relative standing broad jump, for law enforcement recruits (n=94).

		Age	Height	Body Mass	VJ	PAPw	P:BM	SBJ	Relative SBJ
BD Velocity	r	-.212*	.182	.188	.209*	.568**	.489**	.609**	.426**

* Denotes significant ($p < 0.05$) relationship with BD velocity. ** Denotes significant ($p < 0.001$) relationship with BD velocity.

Table 3. Stepwise linear regression controlling for sex for the BD. Variables entered were: age, height, body mass, vertical jump (VJ), PAPw, P:BM, standing broad jump (SBJ), relative SBJ.

Model	r	r2	Significance
Sex	.639	.408	<.001
Sex, SBJ	.792	.628	<.001
Sex, SBJ, PAPw	.824	.668	<.001

DISCUSSION

This is the first known study to examine measures of lower-body power and their relationships to the BD job task in a law enforcement population. It was hypothesized that recruits with greater lower-body power, measured in both the vertical and horizontal planes, would drag the dummy with a faster velocity. This hypothesis was supported to an extent through the significant correlations between select lower-body power measures with BD velocity. Moreover, when controlling for sex, SBJ and PAPw together significantly predicted BD velocity. Nonetheless, the current data also showed some limitations with the strength of relationships, which would suggest that other factors may also be contributing to BD performance (e.g. maximal strength, technique, etc.). The results of this study are important to LEA training staff, as this information can be used to inform training and testing of law enforcement recruits.

The SBJ, when expressed in both absolute and relative terms, exhibited significant correlations with BD velocity when controlling for sex. This was expected, as the goal of the BD is to horizontally move the dummy as fast as possible, and SBJ provides an indirect measure of horizontal power generation (21, 26). It should be noted that as described in the WSTB manual (39), the recruit performs the test while dragging the dummy backwards, whereas the SBJ involves forward motion. Despite these differences in the motion required for the two tests, there was a significant relationship between the forward horizontal power required for the SBJ, and backwards horizontal performance of the BD. These results suggest that adding plyometric exercises such as the SBJ during academy training might be beneficial to enhancing performance in the BD for law enforcement recruits.

In comparison to SBJ, the VJ exhibited significant small positive correlation with BD velocity, which may be explained by two factors. One is the actual act of dragging involves a horizontal use of force, whereas the VJ provides more of an indirect measure of vertical force and power production (11, 40, 41). The second factor is that test protocol itself is designed so that time does not begin until the dummy has already been successfully lifted (39). This may limit the contribution of vertical power to the overall completion of the test as it is conducted within the WSTB. Lifting the dummy straight off the ground, in a fashion similar to a deadlift, may be more related to a recruit's ability to generate vertical power (3, 28, 44, 45). Furthermore, the standardized grip condition necessitates the lifting of the dummy into the upright position. This may reprioritize the important physical characteristics required to successfully drag the dummy, as the recruit will be supporting most of the dummy's weight by lifting it off the ground. It should be noted that there is no literature available that examines the most effective body drag techniques for law enforcement officers, and that the selected standardized grip might not be the most efficient or pragmatic version of this task. Further research should investigate different methods for the BD that LEOs would use in their job, as this could alter the power requirements for this specific job task.

Height and body mass were not significantly correlated with BD velocity by themselves; however, both PAPw and relative SBJ included body mass in their calculations and had significant relationships with BD velocity. This indicates that being more powerful relative to body mass still had some importance for executing the BD. Although it could be expected that physically larger officers may be more effective at a BD, these results highlight the importance of targeted physical training to improve recruit's ability to complete these job-specific tasks. Essentially, it is not just unchangeable physical characteristics such as height that determines BD capability, but also trainable characteristics such as absolute and relative lower-body power.

This focus on proper training is further highlighted through the small, but significant, negative correlation between age and BD velocity. This relationship suggested that older candidates dragged the dummy slower than younger candidates. Age-based differences in law enforcement officers are evident in the literature, with older individuals tending to perform poorer in a range of physical fitness assessments when compared to their younger counterparts (14, 24, 30). This further reinforces the need for appropriate physical training, especially for these recruits that may be starting academy at a lower physical ability level (e.g. older recruits).

The linear regression results suggested that sex by itself explained 41% of the variance; the addition of SBJ and PAPw metrics improved the overall predictive capability of the model to 67%. The influence of sex on the BD task is important to highlight. Literature has consistently shown that males typically perform better than females in many law enforcement assessments (9, 25, 30). LEA staff should ensure a particular focus on the physical development of female recruits, especially as it pertains to the BD. Further to this, the regression model emphasized the importance of horizontal power as measured by the SBJ, and the ability to generate a high level of peak vertical power (PAPw). These qualities are trainable (26, 27, 33, 34), thus all law enforcement recruits should attempt to improve their capacity to generate high lower-body power. This is very important to note for LEA training staff, as academy training can often over-emphasize strength endurance and aerobic capacity (8, 23, 32, 36). Training staff should include power development, along with other physical qualities, in academy training as power could be beneficial for job-specific tasks. For a task such as the BD, power could ultimately be the difference between a rapid successful removal of an injured officer or member of the public from a dangerous situation and the failure to do so.

Limitations to this study should be acknowledged. No measures of lower-body strength were included in this study. Isometric leg and back strength have been measured in law enforcement officers (14), and the US Army uses the hex bar deadlift to measure strength in their recruits (6, 17, 35). Although maximal strength is rarely measured in law enforcement recruits, as strength endurance tasks tend to be emphasized (7), future research should measure strength in law enforcement recruits, and detail how this quality could relate to performance in the BD. Additionally, the structure of this agency's testing only allocated enough time for a single trial of the dummy drag to be completed. LEAs tend to be time poor with regards to physical testing (37), and this can limit the amount and style of tests that can be conducted and equipment that can be utilized (7, 25). Moreover, only one specific starting condition (upright supporting the dummy) and standardized grip were utilized, although this followed the state-mandated requirements for this test (39). Further research is necessary to determine the relationship between the BD performed with different starting and grip conditions (e.g. dragging straight armed, beginning the time as soon as the dummy is contacted) with lower-body strength and power. It should also be noted that these were recruits being tested and not sworn officers. Sworn officers may perform differently on the BD test if they have learnt different BD techniques from working in the field.

In conclusion, the results of this study suggest that when controlling for sex, horizontal power, and power generated relative to body mass in both the vertical and horizontal planes, related to BD velocity. To improve performance of the BD task in the WSTB, recruits should ideally include horizontal and vertical power exercises such as the SBJ or VJ into their training programs. Additionally, it may be more beneficial for female and older recruits to include power training to make up for the sex- and age-based differences that are present (9, 14, 24, 25, 30). Further research should attempt to include measures of maximal lower-body strength, as well as different starting and grip conditions, to further elucidate the physical characteristics required to successfully complete a BD.

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