Short Communication

Backwards overhead medicine ball throw and countermovement jump performance among firefighter candidates

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Objectives: To examine the relationships between performance during a backward overhead medicine ball (BOMB) throw and measures of countermovement jump (CMJ) performance among firefighter candidates.

Design: Cross-sectional study.

Methods: Forty-three firefighter candidates volunteered to participate in this study (age = 28.1 ± 7.1 yrs; height = 180.6 ± 6.0 cm; weight = 88.6 ± 12.3 kg). Bivariate Pearson correlations were used to examine the relationship between BOMB throw performance (m/kg) and measures of CMJ performance, including: peak CMJ height (cm/kg), peak CMJ force output (N/kg), peak CMJ velocity (cm/sec/kg), and peak CMJ power output (W/kg).

Results: Statistically significant ($p < 0.05$) correlations were identified between: BOMB throw and peak CMJ height ($r = 0.693$, $p < 0.001$), peak CMJ force output ($r = 0.349$, $p = 0.022$), and peak CMJ velocity ($r = 0.477$, $p < 0.001$). Although significant relationships were identified between BOMB throw performance and several of CMJ performance measures, BOMB throw performance accounted for little of the total variance between these measures (R^2 = 7–48%). Furthermore, the relationship between BOMB throw and peak CMJ power output was not statistically significant ($r = 0.292$, $p = 0.057$).

Conclusions: These results imply that the BOMB throw lacks criterion-reference validity to other standard field-based measures of power output. Thus, practitioners should exhibit caution when utilizing the BOMB throw to assess power output among firefighter candidates. In addition, future research should examine the criterion-reference validity of other field-expedient assessments among firefighter candidates and active-duty firefighters.

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Key words: power output ■ force output ■ vertical jump height ■ criterion-validity

INTRODUCTION

The occupation of firefighting consists of extremely strenuous physical tasks, such as carrying equipment up stairs; advancing charged hoses; breaking down doors and walls; and rescuing victims.[1] Previous research has demonstrated near-maximal levels of exertion and heart rates during these firefighting-related tasks.[2,3] As such, researchers have suggested that many of the tasks associated with firefighting are anaerobic in nature. In addition, anaerobic power output has recently been demonstrated as a significant predictor of firefighting performance.[3-5] However, few studies have investigated anaerobic power output among the firefighter population. This may be due to a lack of valid and reliable assessments of power output that can be easily and inexpensively applied among firefighter-specific environments.

Recently, several field-expedient assessments of total body power output have been investigated in the literature. One such assessment is the backwards overhead medicine ball (BOMB) throw. During the BOMB throw, the participant attempts to explosively throw a medicine ball as far as possible in a backwards direction.[6] Although the validity of the BOMB throw has been examined among various athlete populations,[7-9] it has yet to be examined among a tactical athlete population, such as firefighters. Furthermore, since total body power output during a vertical jump test has been previously demonstrated as a significant predictor firefighting performance,[4] the BOMB throw may prove to be a useful tool to assess the total body power output among firefighters.

However, before the BOMB throw can be implemented in firefighter domains, the criterion-reference validity of the BOMB throw to another previously established field-based measure of total body power must first be determined among this population. Since the vertical jump test has been previously used to measure total body power output,[10] and since practitioners routinely use the vertical jump test as a common field-expedient method of evaluating total power output,[11] the countermovement jump (CMJ) was used as the criterion-reference in relation to BOMB throw performance. Accordingly, the purpose of this study was to examine the relationship between BOMB throw performance and measures of CMJ performance among firefighter candidates.

METHODS

Subjects

All subjects recruited for the current study ($N = 43$) were

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male firefighter candidates currently enrolled in the same academy training program. Subjects were healthy and free from any injury to or pain in their shoulders, back, hips, knees, or ankles within the past the 3 months. Subjects gave written informed consent before participating and this study was approved by the author's institutional review board.

Procedures

All testing procedures took place on an indoor basketball court in the gym at the Safety Academy of their representative fire department. All subjects completed a 5-minute dynamic warm-up before the start of any testing procedures. Although previous training, diet, and hydration of the subjects were not controlled, the order of the BOMB throw and CMJ protocols were randomized, with 5 minutes of rest given between each testing protocol.

Backwards overhead medicine ball throw

Each subject performed the BOMB throw according to Stockbrugger and Haennel[6] using a 7-inch diameter, 6-lbs, non-bounce rubber medicine ball (Power Systems, Inc., Knoxville, TN) and were instructed to throw the ball backwards overhead and as explosively as possible with a self-selected degree of elbow flexion. Each subject performed 1 practice attempt and 2 trials, with 30-second of rest in-between each throw. The best BOMB throw trial was used for comparison with the CMJ performance measures. Adequate test-retest reliability of the BOMB throw has been previously demonstrated in the literature.[6] To reduce the potential influence of familiarization on BOMB throw performance,[12] all subjects completed a practice BOMB throw protocol 8 weeks before the actual testing protocol. In addition, a *post hoc* paired samples *t*-test indicated there was not a significant difference between the 2 BOMB throw test trials ($t_{42} = -1.207$, $p = 0.234$), suggesting that the previously completed familiarization session and subsequent practice attempt likely minimized any familiarization effect on BOMB throw performance.

Countermovement jump

CMJ performance was measured with the Myotest (Myotest Inc., Durango, CO). The Myotest is a 3-dimensional accelerometer-based device that is attached to an individual's hip and measures peak height (cm), peak power output (W/kg), peak force output (N/kg), and peak velocity (cm/sec) of a vertical jump movement. The validity and reliability of the Myotest in assessing CMJ performance has been previously established in the literature.[13,14]

Each subject performed 2 test CMJ trials, separated by 30 seconds of rest between each trial, according to previously established protocol.[15] Researchers did not control for depth of the countermovement, each subject was instructed to jump as high as possible, and positive verbal encouragement was given. Each subject was allowed several practice CMJ trials to ensure proper technique and to confirm measurement of the CMJ trials by the Myotest. Although previous research suggests that a familiarization session does not impact vertical jump performance among physically-active men,[16] all subjects still completed practice CMJ protocols several weeks before the actual testing protocol. CMJ data were discarded if: (a) the subject started his movement before the beep stimulus; (b) the subject removed his hands from their hips; or (c) the Myotest did not properly measure the CMJ trial. The CMJ trial resulting in the greatest peak height was utilized for all statistical analyses.

Statistical analyses

To account for the influence of body mass, all BOMB throw and CMJ performance measures of each subject were normalized to their respective weight (kg). Four separate bivariate Pearson correlations (r) were then utilized to examine the relationship and measure of common variance (R^2) between BOMB throw performance (m/kg) and the CMJ performance measures of peak CMJ height (cm/kg), peak CMJ force output (N/kg), peak CMJ velocity (cm/sec/kg), and peak CMJ power output (W/kg). An alpha of 0.05 determined statistical significance for all analyses. All statistical analyses were completed using IBM SPSS 20 software (IBM Corp., Armonk, NY) and achieved statistical power ($1 - \beta$) was calculated for each correlation.[17]

RESULTS

Group physical and performance characteristics (mean ± SD) of the CMJ and BOMB throw measures are presented in Table 1. Although normative values of CMJ performance using the Myotest among firefighters have not been previously reported in the literature, Nuzzo et al.[14] reported similar CMJ performance measures among healthy male university students using the Myotest (45.7 ± 6.6 cm). Correlation coefficients (r), measures of common variance (R^2), and achieved statistical power ($1 - \beta$) between BOMB throw performance and the CMJ performance measures are presented in Figure 1. Statistically significant correlations were identified between: BOMB throw and peak CMJ height (Figure 1A; $r = 0.693$, $p < 0.001$, $1 - \beta = 0.204$), BOMB throw and peak CMJ force output (Figure 1B; $r = 0.349$, $p = 0.022$, $1 - \beta = 0.052$), and BOMB throw and peak CMJ velocity (Figure 1C; $r = 0.477$, $p < 0.001$, $1 - \beta = 0.060$). In addition, the correlation between BOMB throw and peak CMJ power

Table 1 Subject physical and performance characteristics ($N = 43$)

Variable	Mean ± SD	Range
Age (yrs)	28.1 ± 7.1	18.0 – 43.0
Height (cm)	180.6 ± 6.0	170.2 – 43.0
Weight (kg)	88.6 ± 12.3	71.2 – 113.4
Body Mass Index (kg/m²)	27.1 ± 3.2	21.2 – 35.1
CMJ Height (cm)	41.6 ± 6.23	28.2 – 55.9
CMJ Force (N/kg)	21.94 ± 2.58	17.4 – 30.1
CMJ Velocity (cm/sec)	238.84 ± 45.93	161 – 344.0
CMJ Power (W/kg)	42.77 ± 11.46	24.0 – 74.0
BOMB Throw (m)	12.62 ± 1.76	17.1 – 9.8

BOMB Throw, backwards overhead medicine ball throw; CMJ, countermovement jump

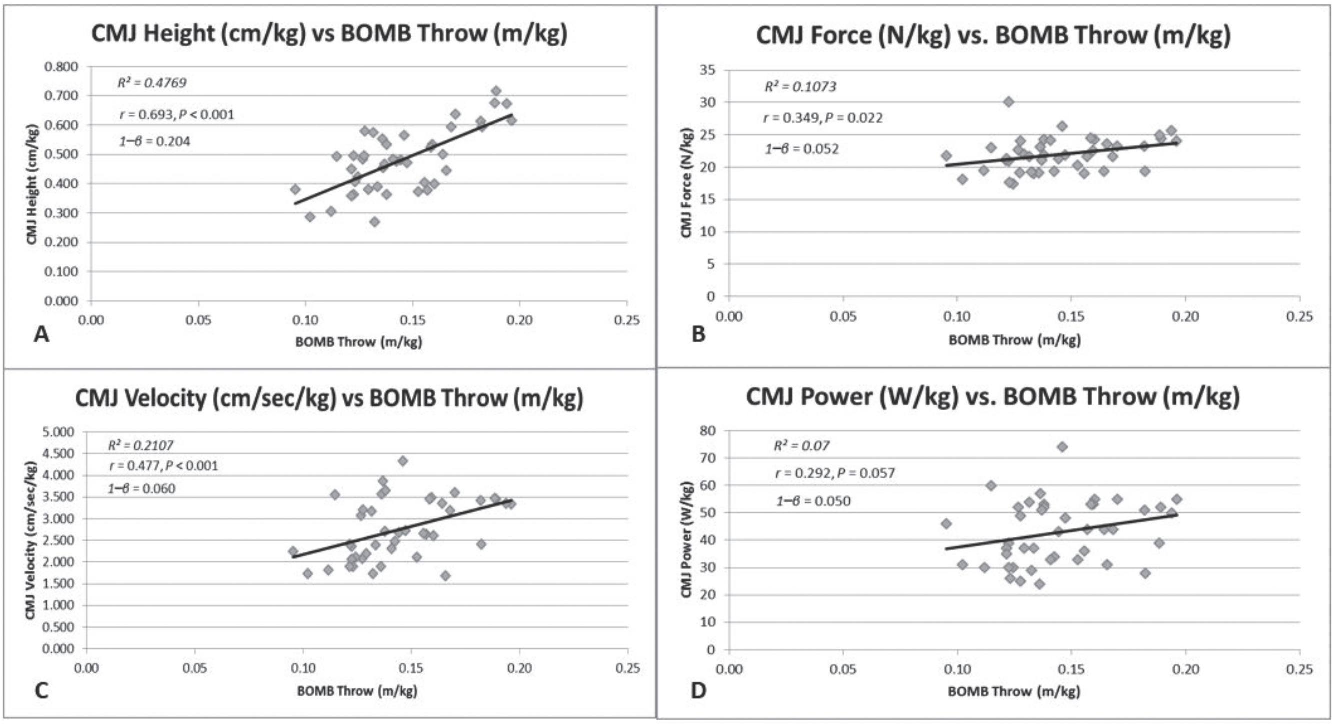

Figure 1 Relationships between backwards overhead medicine ball (BOMB) throw performance and measures of countermovement jump (CMJ) performance.

output was approaching significance (Figure 1D; $r = 0.292$, $p = 0.057$, $1 - \beta = 0.050$).

DISCUSSION

The purpose of this study was to examine the relationship between BOMB throw performance and various CMJ performance measures among firefighter candidates. The results identified significant relationships ($p < 0.05$) between BOMB throw performance (m/kg) and CMJ performance measures, specifically peak CMJ height (cm/kg), peak CMJ force output (N/kg), and peak CMJ velocity (cm/sec/kg). In addition, the relationship between BOMB throw performance and peak CMJ power output (W/kg) was approaching levels of significance ($p = 0.057$). Since previous research has demonstrated that vertical jump power output is a significant predictor of firefighter performance,[5] BOMB throw performance may be a significant predictor of firefighter performance as well. Thus, future research investigating the utility of BOMB throw performance and the prediction of firefighting performance is warranted.

However, when examining the level of common variance (R^2) between BOMB throw performance and the CMJ performance measures, it appears that the BOMB throw only accounts for 7–48% of the total variance among the measures of CMJ performance. This suggests that although the correlations between BOMB throw and CMJ performance may be statistically significant, BOMB throw performance accounts for a low portion of the total variance among the CMJ performance measures. Furthermore, the CMJ performance measure least accounted for by the BOMB throw was peak CMJ power output (7%). As such, criterion-reference validity of the BOMB throw to a previously validated measure of total body power output is lacking among this population of firefighter candidates.

Similar findings have been reported among other populations as well. Mayhew et al.[7] demonstrated that the BOMB throw accounted for only 18% to 40% of the total variance in power output during a vertical jump among collegiate football players. Mayhew et al.[7] also demonstrated a significant relationship ($r = 0.32$, $p < 0.05$) between body mass (kg) and BOMB throw performance (m). This implies that body mass alone is related to CMJ power output as well. The current study attempted to account for this factor by normalizing all performance measures to each subject's body mass (kg). As such, this normalization method may explain the even lower relationship ($R^2 = 0.07$) between BOMB throw and power output in comparison to the previous literature.

Interestingly, the strongest relationship between BOMB throw performance and CMJ performance was the measure of peak CMJ height, which accounted for 48% of the total variance. Previous research has demonstrated that other aspects of dynamic movement, and not simply physiological power output alone, can contribute to vertical jump performance, such as the depth of the countermovement.[18,19] Since the BOMB throw is a dynamic, gross-motor skill that requires coordinated movement of both the lower body and upper body to achieve maximal performance, it is possible that it may be a better indicator of dynamic and coordinated gross-motor skill (i.e., peak CMJ height) than physiological power output.

Potential limitations of the current study involve the sample population investigated. Specifically, previous research has demonstrated that power output is a significant predictor of firefighting performance in active-duty firefighters.[3-5] This study utilized firefighter candidates preparing to become active-duty firefighters. Thus, it is possible that the relationships between BOMB throw performance and measures of CMJ performance may differ between firefighter candidates and active-duty firefighters. Furthermore, no females were enrolled in the academy training program at the time of data collection, and thus, the sample population only consisted of male firefighter candidates. Since the active-duty firefighter population consists of both males and females, this is not a completely representative sample of this fire department.

Accordingly, future research should examine the relationship between BOMB throw performance and measures of CMJ performance among both male and female active-duty firefighters, as well as firefighter candidates, to determine if predictors of CMJ performance differ between these firefighter population groups. In addition, future research should examine other field-expedient assessments of power output and their respective relationships to CMJ and firefighter performance. It is possible that another measure is more predictive of firefighter performance. Identifying this potential measure would help determine the preferred method of assessing power output among the firefighter population.

CONCLUSIONS

Since previous research suggests that anaerobic power output is a significant determinant of firefighter performance,[3-5] practitioners have recently begun recommending that firefighters engage in power training in an attempt to enhance firefighting performance.[20] Thus, valid field-expedient assessments of power output, such as the BOMB throw, are necessary to monitor the impact and efficacy of these training programs on an individual's power output.

This study provides meaningful descriptive data regarding power output performance from two common field-based assessments among firefighter candidates. Although significant relationships were identified between BOMB throw performance and measures of CMJ performance in the current study, these measures accounted for little of the total variance between these assessments. This suggests that the BOMB throw lacks criterion-reference validity in relation to another standard field-based measure of power output. Thus, practitioners should take caution when using the BOMB throw to assess power output among firefighter candidates and the incorporation of several different methods of power output assessment is recommended. In addition, future research should examine other field-expedient assessments of power output and their respective relationships to firefighting performance.

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REFERENCES

1. Gledhill N, Jamnik VK. Characterization of the physical demands of firefighting. *Can J Sport Sci* 1992; 17: 207-213.
2. Sothmann MS, Saupe K, Jasenof D et al. Heart rate responses of firefighters to actual emergencies. *J Occup Med* 1992; 34: 797-800.
3. Sheaff AK, Bennett A, Hanson ED et al. Physiological determinants of the candidate physical ability test in firefighters. *J Strength Cond Res* 2010; 24: 3112-3122.
4. Michaelides MA, Parpa KM, Henry LJ et al. Assessment of physical fitness aspects and their relationship to firefighters' job abilities. *J Strength Cond Res* 2011; 25: 956-965.
5. Rhea MR, Alvar BA, Gray R. Physical fitness and job performance of firefighters. *J Strength Cond Res* 2004; 18: 348-352.
6. Stockbrugger BA, Haennel RG. Validity and reliability of a medicine ball explosive power test. *J Strength Cond Res* 2001; 15: 431-438.
7. Mayhew JL, Bird M, Cole M et al. Comparison of the backward overhead medicine ball throw to power production in college football players. *J Strength Cond Res* 2005; 19: 514-518.
8. Salonia MA, Chu DA, Cheifetz PM et al. Upper-body power as measured by medicine-ball throw distance and its relationship to class level among 10- and 11-year-old female participants in club gymnastics. *J Strength Cond Res* 2004; 18: 695-702.
9. Stockbrugger BA, Haennel RG. Contributing factors to performance of a medicine ball explosive power test: A comparison between jump and nonjump athletes. *J Strength Cond Res* 2003; 17: 768-774.
10. Harman EA, Rosenstein MT, Frykman PN et al. Estimation of human power output from vertical jump. *J Appl Sports Sci Res* 1991; 5: 116-120.
11. Harman E, Garhammer, J. Administration, scoring, and interpretation of selected tests, Chapter 12, in *Essentials of Strength Training and Conditioning*, third edition. Eds. Baechle TR, Earle RW, Champaign, Human Kinetics, 2008.
12. Duncan MJ, Al-Nakeeb Y, Nevill AM. Influence of familiarization on a backward, overhead medicine ball explosive power test. *Res Sports Med* 2005; 13: 345-352.
13. Castagna C, Ganzetti M, Ditroilo M et al. Concurrent validity of vertical jump performance assessment systems. *J Strength Cond Res* 2013; 27: 761-768.
14. Nuzzo JL, Anning JH, Scharfenberg JM. The reliability of three devices used for measuring vertical jump height. *J Strength Cond Res* 2011; 25: 2580-2590.
15. Casartelli N, Muller R, Maffiuletti NA. Validity and reliability of the Myotest accelerometric system for the assessment of vertical jump height. *J Strength Cond Res* 2010; 24: 3186-3193.
16. Moir G, Button C, Glaister M et al. Influence of familiarization on the reliability of vertical jump and acceleration sprinting performance in physically active men. *J Strength Cond Res* 2004; 18: 276-280.
17. Faul F, Erdfelder E, Buchner A et al. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behav Res Methods* 2009; 41: 1149-1160.
18. Harman EA, Rosenstein MT, Frykman PN et al. The effects of arms and countermovement on vertical jumping. *Med Sci Sports Exerc* 1990; 22: 825-833.
19. Salles AS, Baltzopoulous V, Rittweger J. Differential effects of countermovement magnitude and volitional effort on vertical jumping. *Eur J Appl Physiol* 2011; 111: 441-448.
20. Abel MG, Sell K, Dennison K. Design and implementation of fitness programs for firefighters. *Strength Cond J* 2011; 33: 31-42.