

CONCURRENT VALIDITY OF THE BACKWARDS OVERHEAD MEDICINE BALL THROW AS A TEST OF EXPLOSIVE POWER IN ADOLESCENTS

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Abstract

Introduction: Medicine ball throws have been used as a field based test of explosive power. However, few authors have compared medicine ball throw performance to actual power output in young people. The aim of this study was to compare backwards overhead medicine ball (BOMB) throw performance with actual power output in a group of adolescents.

Materials and methods: Following parental informed consent, 47 adolescents (22 boys, 25 girls, mean age $\pm$ S.D. = 12.7 ± 1.5 years) performed the BOMB with a 3kg medicine ball, a counter movement jump (CMJ) and a weighted (7kg bar) squat jump (WSJ) in a randomized order. Power output was determined using a force platform (Kistler, Amherst, New York) and a linear position transducer (Fittech Inc, Australia) in the case of the CMJ and WSJ respectively.

Results: BOMB throw distance was significantly related to CMJ peak power ($r = .806$, $P = 0.001$) and WSJ peak power ($r = .632$, $P = 0.01$). CMJ power ($R^2 = 0.59$, $F_{1,46} = 66.6$, $P = 0.01$) was a better predictor of BOMB throw distance than WSJ power ($R^2 = 0.39$, $F_{1,46} = 29.9$, $P = 0.01$).

Conclusions: These results suggest that the BOMB demonstrates concurrent validity with power output of the lower body (gluteals, quadriceps, hamstrings, calves) in adolescents.

Key words: counter movement jump, force platform, squat jump

Introduction

In a number of domains, such as sport performance and physical education (PE) the ability to generate and transfer explosive power is a key element to success [1, 2]. For example, transfer of power from the lower body to upper body is a requirement in fundamental movement skills such as jumping and hopping as well as more sport specific movement in gymnastics, American football and volleyball [1-3]. Therefore, the evaluation of the various expressions of strength and explosive power is fundamental for enhancing movement performance [1]. The force platform has been widely used to assess power within laboratory settings although its use has been restricted in field settings due its cost and, as a result a number of field measures have been developed to provide movement feedback [2, 4]. These tests include the vertical jump [4], the weighted squat jump [5] the Margaria-Kalman step test [6] and the standing long jump [7]. Medicine ball throws are another testing modality that have received research attention with authors suggesting that other testing modalities do not evaluate integrated total-body power, and do not challenge the kinesthesia necessary in sporting environments [8]. For example, many sporting movements require transfer of power from the lower limbs through the trunk to the upper body including

the volleyball spike and basketball jump shot. The rationale proposed for the BOMB throw as a test of explosive power by Stockbrugger and Haennel [1] was that the BOMB mimics this movement pattern and so would be a more useful field test to assess explosive power than the counter movement jump. Indeed the BOMB was designed to generate forces in the same musculature and movement pattern as the vertical jump [1, 8]. Although greater arm movement in the BOMB throw, compared to a vertical jump, might mean the power generated during the BOMB is greater than an average vertical jump, if the BOMB is a valid test of explosive power it would be expected to be significantly correlated with actual power production in another criterion test of explosive power [2].

Subsequently, medicine ball throw distance has been used in various populations, including children as young as 5 years old, as an indicator of explosive power [3, 9]. Medicine ball throws are attractive, particularly within PE, as they are inexpensive and can more closely mirror the integrated movements that are required in multiple sports. Indeed, there have been recommendations presented on the use of medicine balls within PE as a means to develop fundamental movement skills, a modality of resistance exercise that can be safely used within schools and as an inex-

pensive and rapid way of assessing power in children [10]. However, despite these suggestions and the use of medicine ball throws as measures of explosive power, evidence on the validity of these measures in younger populations is scant. Clearly, if medicine ball throw tests are used within school settings there is a need to establish the validity of such tests with a sample of regular school adolescents or children (as opposed to trained participants).

One study appears to have formed the basis for the validity and reliability of medicine ball throws as a test of explosive power. Stockbrugger and Haennel [8] compared the backwards, overhead medicine ball (BOMB) throw to the countermovement vertical jump in a group of 20 volleyball players aged 16-30 years. They reported an intraclass correlation for test-retest reliability of $R = .996$ for the BOMB throw and documented a strong relationship with both vertical jump height ($r = .808$) and power index ($r = .906$) using the Lewis equation [11]. The researchers concluded that the BOMB throw demonstrates concurrent validity with established tests of explosive power and is therefore a valid tool to assess explosive power. Moreover, Mayhew et al [2] compared BOMB throw distance to power production in College American Football players and reported significant, moderate correlations between BOMB throw distance and peak and average power. When considered relative to body mass BOMB throw distance was not significantly correlated with peak or average power [2]. However, although the BOMB has since been used with adolescent rugby players [12] and Gymnasts [3], no study appears to have acted on recommendations that BOMB throw performance be compared to power determined using direct measures of power assessment such as the force platform [8, 12]. As medicine ball throws appear to be used within school PE settings [10] and with child and adolescent populations [3, 9], it may be useful to establish the validity of such movements in these populations to ensure that movements such as the BOMB throw are valid measures in this population. Therefore, the aim of this study was to compare BOMB throw performance with actual power output in a group of adolescents. We hypothesized that BOMB throw performance would be significantly and positively related to actual power output derived from force platform analysis and therefore demonstrate concurrent validity as a measure of explosive power in adolescents.

Materials and methods

Study Design

The study used a prospective cross sectional design whereby adolescents from a secondary school in England were asked to perform the BOMB, a counter movement jump and a weighted squat jump on a force platform in a randomised order to establish the con-

current validity of the BOMB with previously validated measures of explosive power.

Participants

Following ethics approval, parental and child informed consent, 47 adolescents (22 boys, 25 girls, mean age $\pm$ SD = 12.7 ± 1.5 years, Mean stature and mass $\pm$ SD = 1.51 ± 0.8 m and 49.1 ± 9.8 kg respectively) were randomly sampled from Year 7 in a school in central England. Children were free from musculoskeletal pain and injury and were not from a particular sporting background. Rather they had experience in a variety of competitive team sports and physical activity (football, rugby union, netball, field hockey). A priori statistical power calculations indicated that to detect a large effect size (0.35) at an alpha level of 0.05 and with a desired statistical power of 80% a minimum sample size of 31 was needed.

Procedures

Participants were familiarized with the tests involved and were then asked to perform the BOMB with a 3kg medicine ball, a counter movement jump (CMJ) and a weighted (7kg bar) squat jump (WSJ) in a randomised order. Familiarization of the BOMB was performed following the recommendations of Duncan et al. [12]. This was compared to the CMJ and WSJ as prior research has suggested these are valid and reliable measures of explosive power [4]. Prior to commencing testing procedures, participants completed a standardized warm-up consisting of 5 minutes or low-to-moderate aerobic exercise and dynamic warm-up exercises (2 minutes brisk walking, 3 minutes jogging at a self-selected comfortable pace followed by 9 dynamic stretches as previously described by Faigenbaum et al. [13] as appropriate in preparing adolescents for anaerobic type exercise. Throw distance was taken as a measure of explosive power. Power output was determined using a force platform (Kistler, Amherst, New York) and a linear position transducer (Fittech Inc, Australia) in the case of the CMJ and WSJ respectively. Both methods have been previously validated [14, 15] as objective measures of power during explosive exercise in general and jumping exercises in particular [See 14 for a review]. Each test was performed 3 times with a 5-minute gap between attempts. Explosive power for the purposes of this study was operationalised using the definition provided by Newton and Kraemer [16, p20] as being 'levels of power output produced during a single maximum effort muscle action' which is determined by the ability to develop as much force as possible in a short space of time (rate of force development) and the muscle's (or muscle group's) ability to continue to produce high force output as its velocity of shortening increases [16].

Statistical Analyses

Pearson's product moment correlations were used to examine relationships between the data and regression analysis was also used to compare the ability of the CMJ and WSJ in predicting BOMB throw performance. These were used in accordance with recommendations for establishing concurrent validity of a given measure [17] and in congruence with prior studies examining the validity of BOMB throw performance in adult populations [1, 2]. Independent t-tests were also employed to assess whether there were any gender differences in BOMB throw, CMJ and WSJ performance. Intraclass correlation coefficients (ICC) with 95% confidence intervals, 95% limits of agreement [18, 19] and coefficient of variation were also used to assess the reliability of each of the measures performed by the participants. The Statistical Package for Social Sciences (SPSS, version 15, SPSS, Inc) was used for all analysis.

Results

BOMB throw distance was significantly related to peak power derived from the CMJ ($r = .806$, $P = 0.001$, see Figure 1.) and the WSJ ($r = .632$, $P = 0.01$, see Figure 2.). In regard to relative power output, BOMB throw distance was significantly related to peak power derived from the CMJ ($r = .79$, $P = 0.01$) but not from the WSJ ($r = .203$, $P = .170$). Greater BOMB throw distance was associated with greater peak power outputs from both jump tests. Mean $\pm$ S.D. of BOMB throw, CMJ and WSJ power was 5.6 ± 1.3 m, 2188.2 ± 738.3 Watts and 2017.5 ± 522.8 Watts respectively. However, CMJ power ($R^2 = 0.59$, $F_{1,46} = 66.6$, $P = 0.01$) was a better predictor of BOMB throw distance than WSJ power ($R^2 = 0.39$, $F_{1,46} = 29.9$, $P = 0.01$). Independent t-tests revealed a gender difference in BOMB throw distance ($t = 3.1$, $df = 45$, $P = 0.03$) with males having greater values than females. Mean $\pm$ S.D. of BOMB throw distance was 6.1 ± 1.4 m and 5.1 ± 0.9 m for males and females respectively. There were no gender differences in CMJ ($P = 0.9$) or WSJ ($P = 0.4$) power. Mean $\pm$ S.D. was 2396.9 ± 1081 Watts and 2078.9 ± 433 Watts in males compared to 2365.6 ± 621.6 Watts and 1963.5 ± 594.4 Watts for the CMJ and WSJ respectively.

Intraclass correlation coefficients were $R = 0.89$ (95% confidence intervals = 0.71-0.96) for the BOMB throw, $R = 0.94$ (95% confidence intervals = 0.84-0.98) for the CMJ and 0.84 (95% confidence intervals = 0.6-0.89) for the WSJ indicating good reliability for all measures employed in the study. Furthermore, ratio limits of agreement and scores for coefficient of variation evidenced acceptable agreement between measures indicating little within subject variation on scores on the tests performed. Coefficient of variation was 6.6%, 5.3% and 6.5% for BOMB throw, CMJ and

WSJ and limits of agreement were 4.3%, 7.6% and 8% for BOMB throw, CMJ and WSJ respectively.

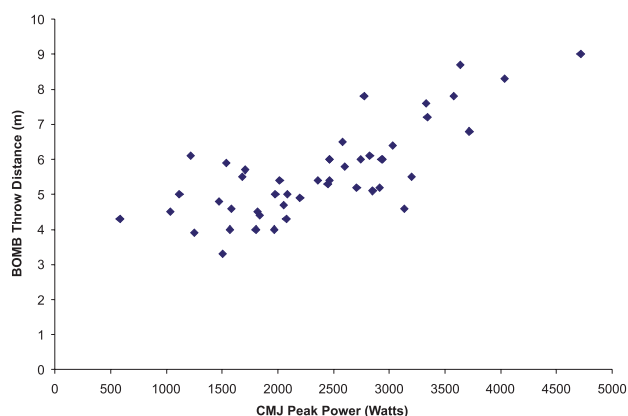


Figure 1. Relationship between BOMB throw distance and CMJ peak power

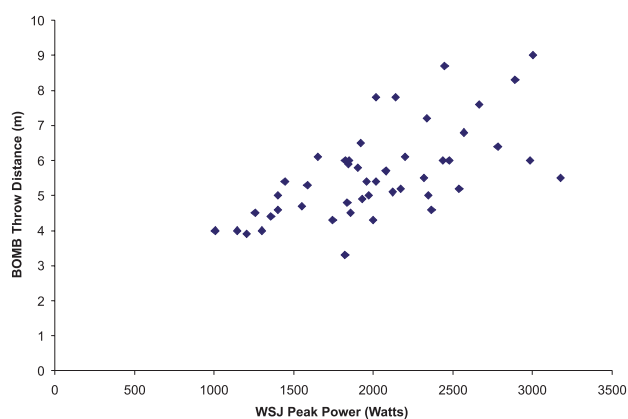


Figure 2. Relationship between BOMB throw distance and WSJ peak power

Discussion

These results support prior studies that have asserted the validity of the BOMB as an estimation of explosive power in their participants [1, 8, 12]. The novel aspect of this study is that, the BOMB demonstrates reliability, concurrent validity with actual power output in young people and therefore shows promise as a field based estimation of explosive power in this population. No study to date has assessed BOMB test validity in children and adolescents despite medicine ball throw being used with this population. These results are similar to those reported by Stockbrugger and Haennel [1, 8] who reported a significant ($r = 0.9$) relationship between BOMB throw distance and CMJ power in adult volleyball players. The results of the current study also agree with previous research by Mayhew et al. [2] who reported significant relationships between BOMB throw performance and peak power output ($r = 0.59$) and mean power output ($r = 0.63$) in American football players. Despite this, the magnitude of the relationships between BOMB throw distance and power output reported by Mayhew et al [2] were lower than those reported in the current study.

Furthermore, when Mayhew et al [2] considered power relative to body mass, no significant correlations with BOMB throw distance were found ($r = 0.27$ and 0.28 for peak and mean power). In the current study relative power output in the CMJ was significantly related to BOMB throw performance whereas relative power output in the WSJ was not. The discrepancy between this finding and the correlation between BOMB throw performance and relative power output reported by Mayhew et al may be due to the participant groups used. In the current study the range of the populations was relatively homogenous, whereas, in the study by Mayhew et al. [2], the large range of body mass of participants (68.8-152.2kg) may have increased the variability of both power output and BOMB throw distance may have contributed to their findings.

The results of the current study also support prior claims made regarding the suitability and usefulness of medicine ball throws in assessing explosive power in children and young people [3, 9]. Notably, in the study by Davis et al [9] they suggested that correlational or known-difference evidence of validity was shown via significant correlations between medicine ball throw distance and height ($r = 0.34$) and mass ($r = 0.34$) and age differences in throw distance in kindergarten children. Research by Salonia et al [3] concluded that there was no difference in medicine ball throw distance irrespective of whether it was thrown backwards overhead or forward overhead in 60, 10-11 year old gymnasts and concluded that either throw could be used by coaches for normative testing. The aforementioned studies [3, 9], used different populations to the present study but the results of the current study would support their claims that medicine ball throws can be used as a means to test explosive power. Specifically, the current study would support this notion in an adolescent population. The BOMB is a practical and low cost alternative to other measures of power testing that can be administered to multiple participants at the same time. Thus, it may be more attractive to PE teachers as an alternative to the vertical jump as a measure of power, particularly as the BOMB uses multiplanar movement (sagittal, frontal) and may be more specific for use in PE compared to a CMJ in terms of the development of gross motor skills, kinesthesia and focus on total body rather than lower body explosive power. However, this study is limited in terms of sample size and participant composition. Future studies are warranted that assess the validity of the BOMB with a range of populations. It would also be beneficial to assess associated contributing factors to BOMB throw distance such as anthropometrical and biomechanical predictors of BOMB throw. Furthermore, both Duncan et al [12] and Mayhew et al [2] have noted that learning effects are present when performing the BOMB. The current study adhered to

recommendations previously published by Duncan et al [12] as the only prior study to have determined practice effects of BOMB throw performance. However, the BOMB throw is a complex coordinated movement and further scrutiny on the practice effect of BOMB throw performance may be warranted to determine the learning and performance curve for different populations in this movement.

There are also other limitations to the present study. This study examined concurrent validity of the BOMB throw in a relatively homogenous sample of adolescents sampled from a PE class. Therefore, the data is limited to this population and further research would be needed to establish the validity of the BOMB throw for athletic testing in trained populations. Furthermore, the BOMB throw was compared to two established tests of lower body explosive power, the CMJ and WSJ, in the current study. By no means does this suggest that the BOMB represents vertical jump power only that the BOMB demonstrates concurrent validity with the CMJ and WSJ. Additionally, in the current study, CMJ power output and WSJ power output explained 59% and 39% of the variance in BOMB throw performance. This would therefore support the notion that the movement pattern used in the BOMB differs from that employed in vertical jumping. The current study did not quantify the contribution of the upper body to BOMB throw distance and it would be beneficial for research to quantify the contribution of upper and lower body segments to BOMB throw performance as well as establishing criterion validity of the BOMB throw as a measure of explosive power in young people.

The evaluation of power output is of interest to exercise physiologists, physical education teachers and coaches and access to low-cost but valid estimations of explosive power are useful for field based fitness testing and athlete monitoring. In this study, the BOMB evidenced concurrent validity with power output derived from a force platform and a counter movement and weighted squat jump. However, this data is specific to the population that participated and so can only be generalised to this group and future studies are needed to evaluate whether the BOMB may be considered a suitable field based estimate of explosive power in children and adolescents more generally.

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