



Original article

# Relationships between Vertical Jump Measurement via a Jump Mat and Jump-and-Reach Device: Implications for Testing in Occupational Health and Wellness Settings

<sup>1</sup>Robert G. Lockie , <sup>1</sup>Rupert M. Scott, <sup>2,3</sup>J. Jay Dawes , and <sup>1</sup>Cullen R. Eckert

<sup>1</sup>Department of Kinesiology, California State University, Fullerton, Fullerton, CA, USA

<sup>2</sup>Department of Health and Human Performance, Oklahoma State University, Stillwater, OK, USA.

<sup>3</sup>Tactical Fitness and Nutrition Lab, Oklahoma State University, Stillwater, OK, USA.

\*Correspondence: [rlockie@fullerton.edu](mailto:rlockie@fullerton.edu)

## Abstract

Different equipment (jump mat [JM], jump-and-reach [JAR] device) can be used to measure the countermovement vertical jump (VJ). Physical space may dictate whether organizations (e.g., first responder wellness programs) can use either equipment, or in some instances, may need to use both. It would be beneficial to determine whether VJ predictive equations can be generated such that data is comparable between assessments using device-specific protocols. Sixty-one physically-active subjects (35 males, 26 females) completed three VJ trials each measured by the JM, JAR device, and the JM and JAR device simultaneously (using the JAR technique; JM-JAR and JAR-JM). A four-way repeated measures ANOVA with Bonferroni post hoc compared the average and best VJ trials across the four jump conditions ( $p < 0.05$ ). Pearson's correlations ( $p < 0.05$ ) calculated between-jump relationships between the conditions. Scatter plots and predictive regression equations for the VJ measured separately (JM, JAR) and simultaneously (JM-JAR, JAR-JM) were derived. For the average and best trials, JM jump height was greater than all other jumps, JM-JAR was greater than JAR and JAR-JM, and JAR was greater than JAR-JM ( $p < 0.001$ ). All correlations were significant ( $r = 0.943-0.981$ ). The predictive equations had ~90% explained variance for the average and best trials, with the separate JM and JAR equations slightly stronger (JM and JAR:  $r^2 = 0.8967-0.9064$ ; JM-JAR and JAR-JM:  $r^2 = 0.8958-0.8745$ ). Even though greater VJ heights were recorded by the JM, given the strong relationships, it is possible to calculate a JAR device measure from a VJ performed on a JM, and vice-versa.

**Keywords:** countermovement jump, health and wellness, occupational health, performance testing, Vertec, vertical jump

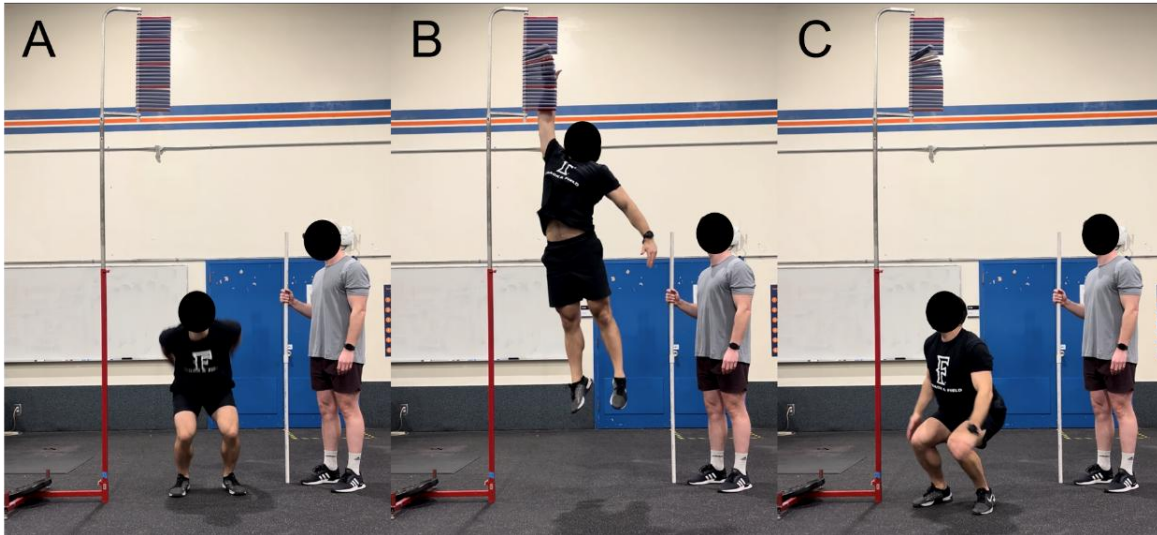
## Introduction

Lower-body power is essential for many tasks that are present in tactical occupations (Lockie et al., 2021b) and sports (Lockie et al., 2016). As a result, lower-body power is an important quality to measure and develop in athletes and tactical personnel. Vertical jump (VJ) tests are often used to extrapolate lower-body power (Lockie et al., 2014), although there has been criticism of using jump height as a metric for this fitness quality (Morin et al., 2019). Nonetheless, jump height has great application for tactical populations. Tactical personnel may need to climb and clear obstacles as part of their profession (e.g., police officers may need to clear fences when pursuing a suspect) (Lockie et al., 2022b). Obstacles will not change their height relative to the power produced by an officer (Lockie et al., 2022b), so absolute jump performance is still relevant for tactical personnel, notwithstanding athletes as well (e.g., basketballers performing a lay-up with a 10-foot [3.05-m] tall hoop). Moreover, VJ assessments are relatively easy to administer (Lockie et al., 2018b), and provide a valid assessment of an individual's physical capacity (Burr et al., 2007).

Different equipment can be used to measure VJ performance, including jump mats (JM) (Lockie et al., 2016), jump-and-reach (JAR) devices (Lockie et al., 2018a), force plates (Buckthorpe et al., 2012), photoelectric cells (Glatthorn et al., 2011), linear position transducers (Wadhi et al., 2018), and smartphone applications (Yingling et al., 2018). JM and JAR devices have been frequently used in research and by professional organizations, and have relatively similar prices (JM: ~\$800; JAR devices: ~\$1000), and are very practical and easy to use (Lockie et al., 2018b). Nonetheless, there are differences in how VJ performance is measured via these two pieces of equipment. The use of a JM involves the performance of a maximal jump and landing on a mat, with VJ height calculated from flight time via projectile motion equations (McFarland et al., 2016) (Figure 1). A JAR device involves displacing vanes and finding the difference between standing reach height and the maximal jump height, typically with a one-armed reach (Figure 2) (Lockie et al., 2014; Lockie et al., 2018b). The actions of the upper-body can vary; the hands can be positioned on the hips throughout the jump to limit the contribution of the upper-body, or they can be used during the countermovement to add momentum to the jump (Walsh et al., 2007). If the goal is maximum jump height, then the arms should be incorporated into the jump (Lees et al., 2006).



**Figure 1.** The vertical jump performed with a jump mat. (A) Counter-movement. (B) Flight. (C) Landing.



**Figure 2.** The vertical jump performed with a jump-and-reach device. (A) Counter-movement. (B) Flight and Reach. (C) Landing.

Physical space (i.e., the space/room available for fitness testing) can be an influencing factor as to whether an organization can use a JM or JAR device. This is a particular concern for tactical organizations such as police or fire departments, where space can often be at a premium (Lockie et al., 2021a). Restricted, or lack of, space could be problematic for companies that could collect data across multiple sites, such as organizations that provide health and wellness programs for first responders. A component of health and wellness programs often include health and fitness assessments, and data can be compiled over a number of years (Lockie et al., 2022c). If data collection procedures need to change, it would be beneficial to utilize data from previous years, regardless of collection method. Moreover, different law enforcement organizations may use different methods to measure the VJ (Myers et al., 2019). It would be beneficial to determine whether accurate predictive equations can be generated such that data is comparable with different methods of assessment (i.e., VJ measured by a JM or JAR device).

There has been some analysis of this in the literature (Buckthorpe et al., 2012; Leard et al., 2007). Leard et al. (2007) compared VJ performance measured by a JM and JAR device to a 3-camera motion analysis system, with measurement occurring on the same jumps performed with a JAR technique. However, as noted previously, the JM technique can be (and is typically) performed with both arms moving during the counter-movement and without the subsequent single-arm reach at peak height (Lees et al., 2006; McFarland et al., 2016; Walsh et al., 2007). Buckthorpe et al. (2012) analyzed jumps performed by healthy adults with a JM and JAR device with a criterion method device of a force plate but did not directly compare the VJ measured by a JM and JAR device. Nuzzo et al. (2011) compared the jump performance of university students recorded by a JM and JAR device simultaneously and found that greater maximum jump heights were recorded by the JM (men: JM =  $57.3 \pm 9.0$  centimeters [cm]; JAR device:  $49.8 \pm 9.1$  cm; women: JM =  $38.3 \pm 6.0$  cm; JAR device =  $31.7 \pm 5.9$  cm). However, the jump technique used by Nuzzo et al. (2011), which was a counter-movement followed by a two-hand reach to contact the JAR device, is not typical and may not be optimal for either the JM or JAR device. It would be beneficial to directly compare VJ height measured via both devices and procedures specifically used in tactical populations (i.e., a jump technique that is theoretically used to optimize the VJ for each device), including a jump mat (Dawes et al., 2019a; Dawes et al., 2019b; Lockie et al., 2019c) and JAR device (Beck et al., 2015; Collins et al., 2022; Hernandez et al., 2021; Lockie et al., 2019a; Lockie et al., 2018a). This research could assist with developing fitness profiles for VJ performance and lower-body power, that may be measured in different ways at different sites due to logistical considerations. This

type of analysis could also allow for comparisons across tactical organizations that may use different VJ data collection procedures.

Therefore, the purpose of this study was to determine the differences, relationships, and predictive equations produced by VJ height measured by a JM and JAR device using protocols specific to each device. An additional point of analysis was to determine whether the differences, relationships, and predictive equations generated from the same jump performed on a JM with a JAR device (i.e., simultaneous measurement; the participant performed a maximal jump and reach on a JAR device while taking off from and landing on a JM) (Leard et al., 2007; Nuzzo et al., 2011), was similar to jumps performed with a JM and JAR device with their specific protocols. It was hypothesized that VJ height measured by a JM and JAR device would be significantly different whether measured separately or simultaneously (Buckthorpe et al., 2012; Leard et al., 2007; Myers et al., 2019). It was further hypothesized that there would be significant relationships and predictive equations for VJ height measured by a JM or JAR device separately or simultaneously, although the relationships and predictive equations would be stronger for the jumps measured simultaneously.

## **Methods**

### **Design**

A cross-sectional analysis was conducted on physically-active men and women who performed three trials each of the VJ measured by a JM, JAR device, and JM and JAR device simultaneously. This study has a focus on VJ data collection procedures from tactical research (although there is clear application for athletic testing). Accordingly, as per previous research, civilians were used as a surrogate population for research for tactical personnel (Lockie et al., 2019b; Lockie et al., 2020b; Mala et al., 2015; Stevenson et al., 2017). A four-way repeated measures analysis of variance (ANOVA) compared the average and best VJ trials recorded from the JM, JAR device, and JM and JAR device simultaneously. Pearson's correlations and predictive regression analyses were used to document relationships between VJ height measured by the four jump conditions.

### **Participants**

Sixty-one physically-active participants (age:  $24.20 \pm 3.78$  years; height:  $1.70 \pm 0.11$  m; body mass:  $74.16 \pm 14.15$  kg), including 35 males (age:  $24.41 \pm 3.46$  years; height:  $1.76 \pm 0.10$  m; body mass:  $81.11 \pm 13.66$  kg) and 26 females (age:  $23.90 \pm 4.25$  years; height:  $1.63 \pm 0.07$  m; body mass:  $64.80 \pm 8.26$  kg) were recruited for this study. Participants were recruited via word-of-mouth from the university campus where the study was conducted. To satisfy inclusion criteria, participants self-reported whether they completed the minimum recommended physical activity for cardiorespiratory and musculoskeletal fitness as detailed by the American College of Sports Medicine (Garber et al., 2011), and were free from injuries that could influence study participation. As stated, previous research has used civilians as a surrogate population for research directed towards tactical populations (Lockie et al., 2019b; Lockie et al., 2020b; Mala et al., 2015; Stevenson et al., 2017). That formed part of the reason why physically-active participants were recruited for this study. Further, the recruitment from the general population allowed for a proportion of males and females with different physical capabilities to be analyzed (Lockie et al., 2020b; Stevenson et al., 2017). Previous research has used 39-135 participants to conduct similar research to that from the current study (Buckthorpe et al., 2012; Leard et al., 2007; Lockie et al., 2022b; Yingling et al., 2018), and the current sample size fell within this range. G\*Power software (v3.1.9.2, Universität Kiel, Germany) was used to confirm post hoc that the sample size of 61 was sufficient for a within factors, repeated measures ANOVA such that data could be interpreted with a small effect level of 0.1 (Hopkins, 2004), and a power level of 0.99 when significance was set at 0.05 (Faul et al., 2007). For documenting relationships between the VJ performed with different methodologies, G\*Power software confirmed post hoc that the sample size of 61 was sufficient for a correlation, point biserial model, and ensured the data could be interpreted with a moderate effect level of 0.35 (Hopkins, 2004), and a power level of 0.81 when significance was set at 0.05 (Faul et al., 2007). The institutional review board approved the

study (HSR-18-19-586), all participants received a clear explanation of the procedures. This included the risks and benefits of participation, and written informed consent was obtained.

### **Measurements and Procedures**

Data was collected in one ~40–45-minute session. Participants were informed to wear athletic clothing and shoes that they would typically use for training (i.e., sneakers). All testing was conducted in the university's Human Performance Lab, which had rubberized flooring. Prior to testing, participants signed an informed consent form and completed a physical activity readiness questionnaire. Participants removed their shoes so height could be measured using a stadiometer (Detecto, Webb City, MO, USA), and body mass could be measured by an electronic digital scale (Model HBF-510, Omron Healthcare, Kyoto, Japan). After this, participants put their shoes back on and completed a dynamic warm-up that lasted approximately 8-10 minutes. All participants completed the same dynamic warm-up prior to the testing session, which comprised of skips with arm swing, side jacks with arm swing, lunge to rotation with hamstring stretch, pigeon stretch, A-skips, cariocas, and five bilateral base drops with arm swing.

The procedures for this study were adapted from previous research (Buckthorpe et al., 2012; Nuzzo et al., 2011). To counterbalance the sample, participants alternated whether they completed the VJ with the JM or JAR device first. All participants completed the VJ that was performed with the JM and JAR device simultaneously last in the testing order. This was because the focus of the study was documenting the relationships between the VJ measured with the specific protocols for the JM (Dawes et al., 2019a; Dawes et al., 2019b; Lockie et al., 2019c) and JAR device (Beck et al., 2015; Collins et al., 2022; Hernandez et al., 2021; Lockie et al., 2019a; Lockie et al., 2018a) as they have been completed previously in tactical research. For each set of jumps, participants completed two warm-up or practice jumps using the specific procedures for the device (i.e., JM, JAR device, or JM and JAR device combined). This helped prepare the participants for the required maximal effort jumps, and also allowed the researchers to correct any flaws in VJ technique (Nuzzo et al., 2011). Following this, participants completed three VJ trials with the particular device, with rest times of 60 seconds allocated between jumps (Buckthorpe et al., 2012; Nuzzo et al., 2011).

### **Jump Mat (JM)**

Established procedures were used to measure the VJ with the JM (Just Jump, Probotics Inc., Huntsville) (Dawes et al., 2019a; Dawes et al., 2019b; Lockie et al., 2019c). The procedures used in this study also have high reliability (intra-class correlation coefficients > 0.9; coefficient of variation ≤5%) (Nuzzo et al., 2011). The participant initially stood on the jump mat keeping their heels on the floor, before completing a countermovement and jumping as high as possible (Figure 1). No preparatory step was used, and no restrictions were placed on the countermovement range. Participants were instructed to use their arms during the jump, as the arms would generally be used when jumping during a match to add angular momentum (Walsh et al., 2007). Participants were instructed to maintain straight legs during the flight, before landing on both feet with flexion of the hips, knees, and ankles. Within the software for the mat, jump height was estimated from flight time via the following equation:  $Jump\ Height\ (m) = (\frac{1}{2} \times acceleration\ due\ to\ gravity [-9.81\ m \cdot s^{-2}] \times [total\ flight\ time \div 2]^2)$ .

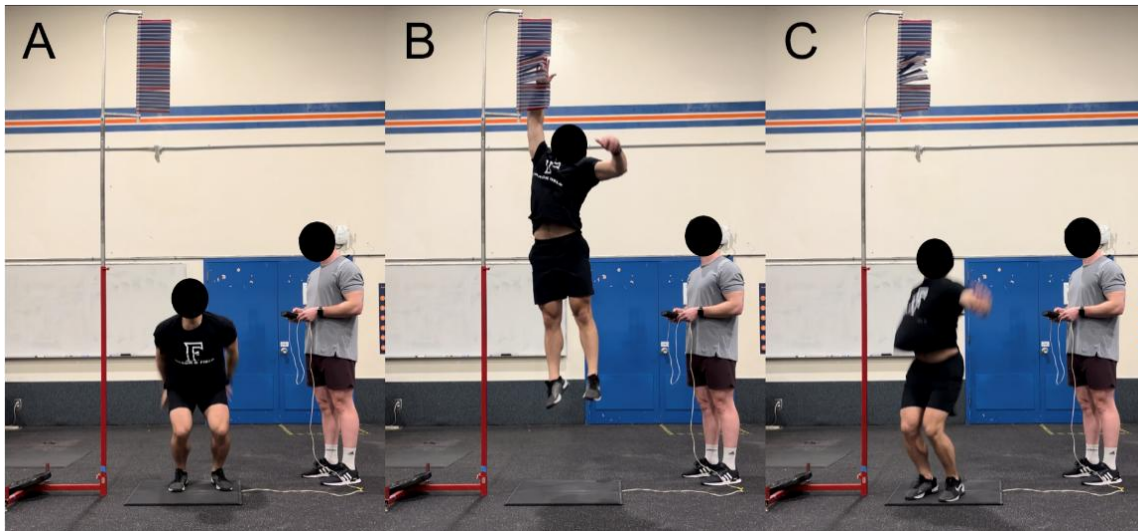
### **Jump-and-Reach Device (JAR)**

As for the JM device, established protocols were used to measure jump height via the JAR device (Vertec Jump Trainer, Perform Better, West Warwick, RI) (Beck et al., 2015; Collins et al., 2022; Hernandez et al., 2021; Lockie et al., 2019a; Lockie et al., 2018a). The protocol used in this study has very high test-retest reliability ( $r > 0.99$ ) (Beck et al., 2015). The participant started by standing side-on to the JAR device on their self-reported dominant side, reached upward as high as possible, and fully elevated the shoulder to displace as many vanes as possible. The participant's heels were to remain in contact with the ground during the reach. The last vane moved became the zero reference. The participant then jumped as high as possible, with no preparatory step, and jump height was recorded from highest vane moved (Figure 2). No restrictions were

placed on the countermovement range. VJ height was calculated in inches by subtracting the standing reach height from the jump height, before being converted to cm.

### Jump Mat and Jump-and-Reach Device Combined

The final jump trials were performed with the jumps measured simultaneously by the JM and JAR device. The procedures for the jump were the exact same as for the JAR device (Beck et al., 2015; Collins et al., 2022; Hernandez et al., 2021; Lockie et al., 2019a; Lockie et al., 2018a), except participants were also required to take off and land on the JM (Figure 3). The mat was positioned on the floor adjacent to the JAR device and below the vanes (Leard et al., 2007; Nuzzo et al., 2011). If the participant did not land centrally on the mat (i.e., one foot also contacted the ground), the trial was disregarded and reattempted. Data recorded from these methods was defined as JM-JAR (jump measured from the JM) and JAR-JM (jump measured from the JAR device).



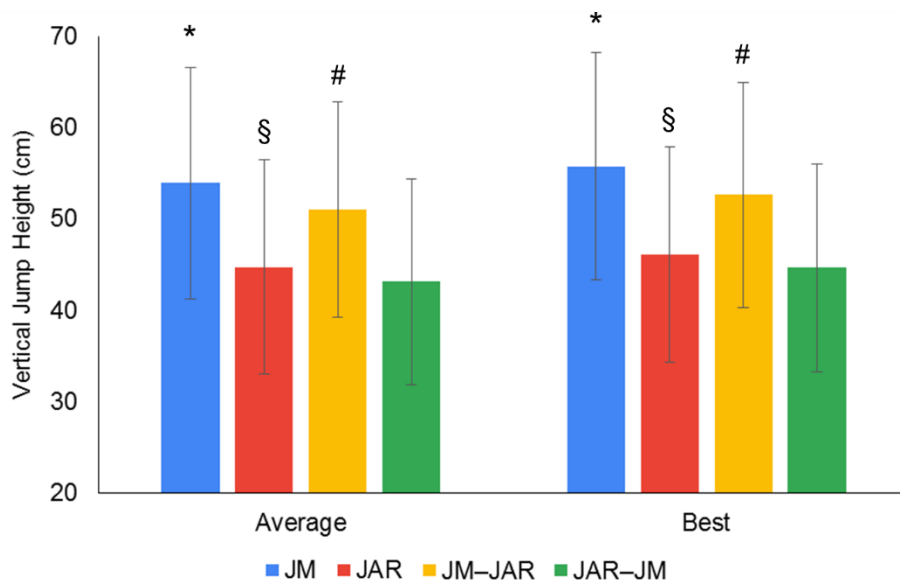
**Figure 3.** The vertical jump performed with a jump-and-reach device and jump mat simultaneously. The vertical jump performed with a jump-and-reach device. (A) Countermovement. (B) Flight and Reach. (C) Landing.

### Statistical Analyses

All statistical analyses were computed using the Statistics Package for Social Sciences (Version 29.0; IBM Corporation, New York, USA) and Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA). Descriptive statistics (mean  $\pm$  standard deviation [SD]) were calculated for VJ height across the four different conditions (i.e., JM, JAR, JM-JAR, and JAR-JM). Males and females were combined in the sample. Normality of the data was evaluated by the Kolmogorov-Smirnov test and visual analysis of Q-Q plots. Analysis was conducted on the average from the three trials from each condition, as well as the best trial. A four-way repeated measures ANOVA, with Bonferroni post hoc for multiple comparisons, was used to compare the average and best VJ trials across the four jump conditions. Significance was set as  $p < 0.05$ . Pearson's correlations ( $p < 0.05$ ) calculated between-jump relationships between the JM, JAR, JM-JAR, and JAR-JM. The correlation strength was designated as: an  $r$  between 0 to  $\pm 0.3$  was small;  $\pm 0.31$  to  $\pm 0.49$ , moderate;  $\pm 0.5$  to  $\pm 0.69$ , large;  $\pm 0.7$  to  $\pm 0.89$ , very large; and  $\pm 0.9$  to  $\pm 1$  near perfect for relationship prediction (Hopkins, 2006). Lastly, scatter plots were produced in Microsoft Excel for the VJ measured separately (JM and JAR) and simultaneously (JM-JAR and JAR-JM). A line of best fit and predictive regression equations were produced for each scatter plot.

## Results

The Kolmogorov-Smirnov test data indicated all jump variables were normally distributed ( $p = 0.200$ ), which was also confirmed upon observation of the Q-Q plots. Thus, parametric statistics were used in this study. The VJ data is shown in Figure 4. There was a significant main effect for the average ( $F_{(3,58)} = 141.157, p < 0.001, \eta p^2 = 0.880$ ) and best ( $F_{(3,58)} = 145.502, p < 0.001, \eta p^2 = 0.883$ ) jumps. Pairwise comparisons indicated that there were significant ( $p < 0.001$ ) differences between all the jumps whether it was the average or best trial. For both the average and best trials, JM jump height was greater than all other jumps, while the JM–JAR was greater than the JAR and JAR–JM. The JAR was greater than the JAR–JM. For the average values, the VJ recorded separately by the JM was 21% greater than that from the JAR device. When the VJ was measured simultaneously, there was an 18% difference.



\* Significantly ( $p < 0.001$ ) greater than the JAR, JM–JAR, and JAR–JM.

# Significantly ( $p < 0.001$ ) greater than the JAR and JAR–JM.

§ Significantly ( $p < 0.001$ ) greater than the JAR–JM.

**Figure 4.** Descriptive data (mean  $\pm$  SD) for the average and best vertical jump recorded from three trials performed by physically-trained men and women ( $N = 61$ ) and measured by a jump mat (JM), jump-and-reach (JAR) device, and jump mat and jump-and-reach device simultaneously (JM–JAR and JAR–JM).

All correlations were significant with near perfect relationships for both the average (Table 1) and best (Table 2) VJ trials across the jump conditions. Figure 5 displays the scatter plot and regression equations for the VJ recorded from the JM–JAR and JAR–JM. There was 89.58% and 87.45% explained variance for the average and best trials, respectively. Figure 6 displays the scatter plot and regression equations for the VJ recorded from the JM and JAR. The explained variance was slightly higher for the JM and JAR relationships, with 89.67% and 90.64% explained variance for the average and best trials, respectively. The equations to predict VJ height for the JAR based on JM performance, and vice-versa, were:

$$JAR_{Average} = (0.875 \times JM_{Average}) - 2.4356$$

$$JM_{Average} = (JAR_{Average} + 2.4356) \div 0.875$$

$$JAR_{Best} = (0.9018 \times JM_{Best}) - 4.1544$$

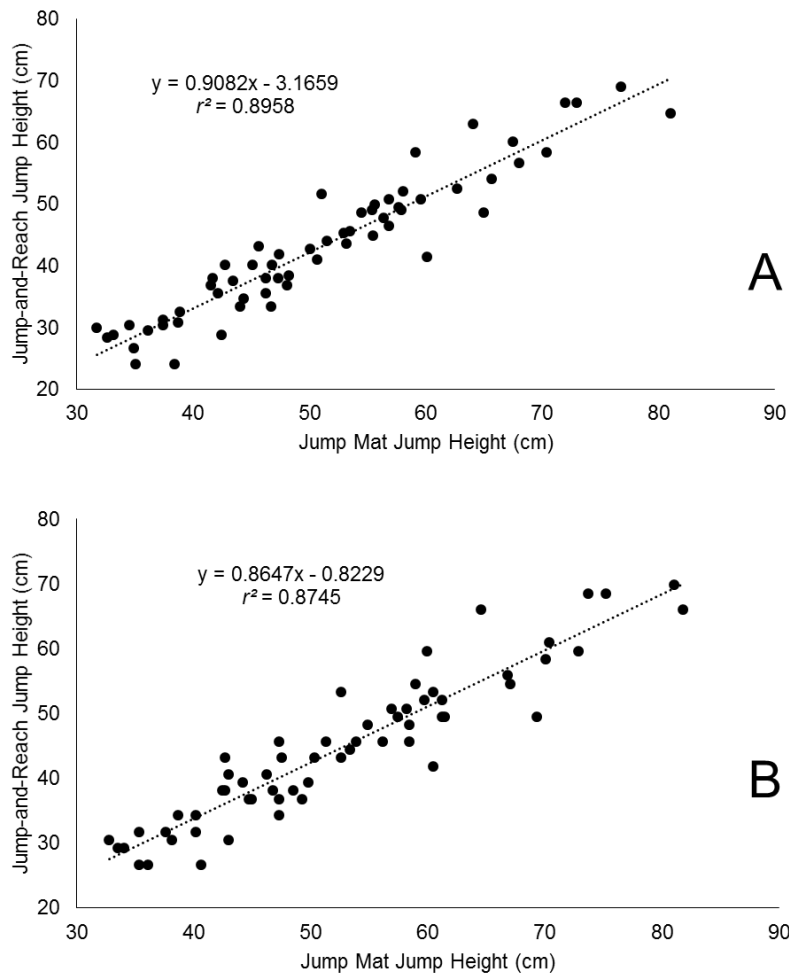
$$JM_{Best} = (JAR_{Best} + 4.1544) \div 0.9018$$

**Table 1.** Correlations ( $r$ ) between the average vertical jump height measured from three trials performed by physically-trained men and women ( $N = 61$ ) and measured by a jump mat (JM), jump-and-reach (JAR) device, and jump mat and jump-and-reach device simultaneously (JM-JAR and JAR-JM). All relationships were significant at  $p < 0.001$ .

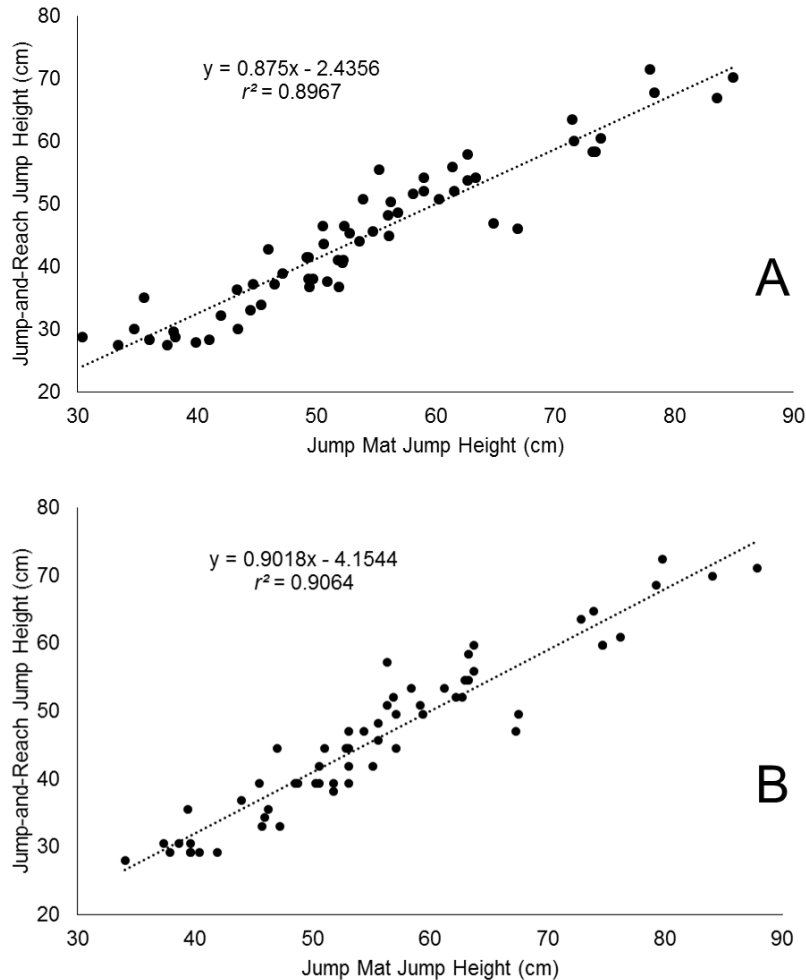
	JM	JAR	JM-JAR
JAR	0.947		
JM-JAR	0.955	0.958	
JAR-JM	0.943	0.981	0.946

**Table 2.** Correlations ( $r$ ) between the best vertical jump height measured from three trials performed by physically-trained men and women ( $N = 61$ ) and measured by a jump mat (JM), jump-and-reach (JAR) device, and jump mat and jump-and-reach device simultaneously (JM-JAR and JAR-JM). All relationships were significant at  $p < 0.001$ .

	JM	JAR	JM-JAR
JAR	0.952		
JM-JAR	0.946	0.955	
JAR-JM	0.931	0.978	0.935



**Figure 5.** Scatter plot and regression equations for the average (A) and best (B) vertical jump recorded from three trials performed by physically-trained men and women ( $N = 61$ ) and measured by a jump mat and jump-and-reach device simultaneously (JM-JAR and JAR-JM).



**Figure 6.** Scatter plot and regression equations for the average (A) and best (B) vertical jump recorded from three trials performed by physically-trained men and women ( $N = 61$ ) and measured by a jump mat (JM) and jump-and-reach (JAR) device.

## Discussion

This study investigated the differences, relationships, and predictive equations produced by VJ height measured by a JM and JAR device separately or simultaneously (i.e., the VJ was measured by the JM and JAR device at the same time). It was hypothesized that VJ height measured by a JM and JAR devices would be significantly different and that there would be significant relationships and predictive equations for VJ height measured by the JM or JAR devices. The results generally supported these hypotheses. Similar to previous research (Leard et al., 2007; Nuzzo et al., 2011), a greater VJ was recorded by the JM compared to the JAR device. There were near perfect correlations between the jumps measured across all conditions, and the explained variance for the average and best trials when comparing jumps from the JM and JAR device measured either separately or simultaneously was also very high ( $r^2 = 0.8745$ - $0.9064$ ). As will be discussed, these results have implications for practitioners who use either a JM or JAR device in their testing, and how they could calculate VJ measurements to predict performance in the other device.

Measuring VJ performance with the JM resulted in the highest jump height. This was expected given the technique required for the jump (i.e., the JM involved a maximal jump without a reach) as well as the projectile motion calculations used to derive the final metric. Flight time recorded via a JM may be longer than other

devices such as a force plate, which contributes to a greater derived VJ (Whitmer et al., 2015). Further, reach displacement can influence jump heights recorded via a JAR device (Ferreira et al., 2010), and poor reach technique could negatively impact the final jump height that is recorded. Leard et al. (2007) and Nuzzo et al. (2011) found 10-21% greater jump heights recorded by a JM compared to a JAR device, which was comparable to the current study (18-21%). There was a study that found contrasting findings (Whitmer et al., 2015). In an analysis of 35 college students, Whitmer et al. (2015) found no significant differences between jumps measured from a JM or JAR device ( $\sim 50 \pm 12$  cm vs.  $\sim 48 \pm 11$  cm), although the VJ recorded by the JM was approximately 4% greater. Nonetheless, the data from the current study suggested that VJ height recorded from a JM will generally be greater than that from a JAR device. If organizations and staff have to use different devices across different locations, the VJ data they record cannot be directly compared. A correction factor or predictive equation would need to be used to calculate comparable data (within the context that the data has been calculated rather than directly measured).

In support of the potential for the use of predictive equations, the results from this study indicated that the average and best jumps were highly correlated (near perfect relationships above 0.90). Previous research has also documented correlations above 0.90 for jumps recorded from a JM and JAR device (Whitmer et al., 2015). These near perfect relationships occur even though different jump techniques were used for the JM and JAR device. Thus, an individual who has a good VJ as measured by the JM should also have a good VJ when measured by a JAR device. The significant relationships were reflected in the predictive equations generated for both the average ( $JAR_{Average} = (0.875 \times JM_{Average}) - 2.4356$ ;  $JM_{Average} = (JAR_{Average} + 2.4356) \div 0.875$ ) and best ( $JAR_{Best} = (0.9018 \times JM_{Best}) - 4.1544$ ;  $JM_{Best} = (JAR_{Best} + 4.1544) \div 0.9018$ ) VJ, which both had explained variances of approximately 90%.

Practitioners could use these equations in several different scenarios. For example, these equations could also be used by practitioners who wish to compare their personnel to those from other organizations, even though they may have used different jump methodologies to collect their data (Myers et al., 2019). Historical VJ data could still be used, even if coaches must change their jump testing equipment due to spacing or cost considerations. One of the factors behind conducting this study is that some health and wellness organizations, researchers, and practitioners who work with first responders will often need to travel to different locations to conduct their testing. Physical space is often at a premium; some testing locations could accommodate a JAR device, while others may not (Lockie et al., 2021a). Moreover, some first responder organizations will purchase and use a JM (Dawes et al., 2019a; Dawes et al., 2019b; Lockie et al., 2019c), while others may only have JAR devices (Collins et al., 2022; Hernandez et al., 2021; Lockie et al., 2019a; Lockie et al., 2018a). The equations documented in this study could allow for greater flexibility in data interpretation, as calculations could be made such that JM or JAR device jump data could be converted and analyzed. However, caution should still be exercised when using data derived from predictive equations, and the error that may exist. For example, as noted the JM uses a projectile motion equation within internal software to calculate jump height (McFarland et al., 2016). Using a predictive equation to then estimate a JAR device measure would involve using a calculation upon a calculation. One situation where this could be impactful is that some first responder health and wellness programs may offer rewards or incentives based on their fitness test performance (Lockie et al., 2022a; Lockie et al., 2022c). There could be errors associated with using calculations to estimate VJ performance, so staff should make their decisions for rewards or incentives within this context.

A novel part of this study included the measurement of a VJ performed with a JM and JAR device simultaneously, using the typical technique for the JAR device. This did result in an atypical movement when considering the JM measurement (i.e., jumping and reaching for a target on the JM, as opposed to just a maximal jump), although a similar jump has been performed in other research (Nuzzo et al., 2011). As previously stated, Nuzzo et al. (2011) used a two-hand rather than one-hand reach, although the one-hand

reach has been suggested as the more appropriate technique for accurate jump measurements (Ferreira et al., 2010). Regardless, there was still a significant difference between the jump height measured by the JM and JAR device when performed simultaneously. There were near perfect relationships between the JM–JAR and JAR–JM (and with the JM and JAR) average and best jump measurements. Interestingly, the explained variance between the JM–JAR and JAR–JM were slightly lower than that for the JM and JAR (average: 89.58% vs. 89.67%; best: 87.45% vs. 90.64%). Thus, the predictive relationships for the JM and JAR were good even with different jump techniques performed at different times. If anything, the results from this study suggest practitioners should use the most appropriate technique specific to the device used to optimize jump performance (i.e., when using a JM, use a countermovement and free arm swing; when using a JAR device, use a countermovement and one-arm reach).

There are study limitations that should be noted. There are potential issues with using VJ height as a metric for power (Morin et al., 2019). However, and as noted, jump height is often used by tactical organizations for both cadets/recruits (Dawes et al., 2019b; Lockie et al., 2019a; Lockie et al., 2020a) and in-service personnel (Dawes et al., 2023; Lockie et al., 2022c). Furthermore, absolute jump performance is important for the completion of job tasks (e.g., clearing an obstacle) (Lockie et al., 2022b). Therefore, the results from this study have clear application. Other devices (e.g., force plates) could provide more accurate measurements of jump performance (Buckthorpe et al., 2012; Ferreira et al., 2010). Regardless, the devices used in this study are common in the field and more affordable and time efficient for many organizations (Lockie et al., 2018b), especially police and fire departments. The sexes were combined in this study. It is possible that different relationships and predictive equations could exist specific to men and women. Nonetheless, the focus of this study was to focus on the test output (i.e., VJ height) measured by each device. The sample for the study was physically-active men and women, although application to first responders and tactical professionals was discussed. Even with tactical professionals being drawn from the general population (as the study participants were), it is possible that tactical personnel could produce different jump data and relationships. Nevertheless, the physical qualities important for a task such as the VJ should be similar whether they are performed by tactical personnel or the general population (Lockie et al., 2019b; Lockie et al., 2020b; Stevenson et al., 2017). As a result, the JM and JAR device relationships and predictive equations should still be applicable.

## Conclusion

The results from this study demonstrated that the JM typically recorded higher average and best VJ trials, which may be a function of the technique during the jump (i.e., arm drive with countermovement, with no need to reach for a target) and use of projectile motion equations to calculate jump height. However, there were near perfect relationships between a VJ measured by a JM or JAR device, and regression equations could be explained with approximately 90% variance. Thus, an individual with a good VJ as measured by a JM should also have a good VJ when measured by a JAR device. These results have applications for practitioners, especially those involved with tactical or first responder organizations where fitness testing can be conducted across multiple sites with different equipment. It is possible to produce predictive equations where a JAR device measure can be derived from a VJ performed on a JM, and vice-versa. This study presented equations for average and best VJ trials that could be used for this process. Practitioners could also consider developing their own predictive jump equations specific to their personnel. However, any decisions made using predicted VJ performance (i.e., provisions or restriction of rewards as part of a health and wellness program) should be exercised within the context that the results have been calculated and not necessarily directly measured.

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