A COMPARISON OF COUNTERMOVEMENT VERTICAL JUMP CHARACTERISTICS BETWEEN JUMP CONDITIONS IN A RECREATIONALLY TRAINED POPULATION; A HYPOTHESIS GENERATING STUDY

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INTRODUCTION: The tracking of physiological characteristics over time is understood as an important and necessary technique to appropriately assess adaptations. The variables that are deemed important to track include: anthropometrics; physical abilities; physiological markers, biochemical markers; etc. This list however can differ based on the population being evaluated and/or what the researcher(s) or client(s) want to know. Further, the tracking of characteristics has grown in popularity along with the rise of the field of sport science (Ache Dias, et al, 2011; Klavora, 2000; Kraska, et al, 2009; and Vuk, et al, 2012). Sport science (a specific derivative of the burgeoning field of Exercise Science) in its truest sense is aimed to enhance sport performance (or sport equipment) through the application of scientific methods and principles. One of the basic tenets of a good sport science professional is the tracking, or long term monitoring, of physical and physiological characteristics of their clients/athletes. This work follows that precept via evaluations of the countermovement vertical jump (CMJ) and its identifiable characteristics. More specifically, the purpose of this work was to compare CMJ characteristics (jump height & average jump power/body mass) between loaded jumping conditions (0kg, 5kg, 10kg, 15kg, & 20kg). This work is part of a larger, ongoing, hypothesis generating study intended to: (1) identify CMJ characteristics worthy of tracking over time; (2) identify tools best suited to track CMJ characteristics over time; (3) expand the data on CMJ across multiple populations; and (4) elucidate any unique results from a recreationally trained population.

METHODS: Thirty-three recreationally trained individuals (males, n = 13: 21.84(±1.51) years; 179.56(±6.43) cm; 90.50(±23.20) kg; females, n = 20: 21.95(±2.52) years; 165.07(±5.53) cm; 68.38(±8.56) kg), free of any musculoskeletal injury that would adversely affect vertical jumping, participated in this study. Prior to the testing session, all participants read and signed informed consent and health history documents, which were approved by the Coastal Carolina University's Institution Review Board.

Participants' anthropometrics were collected first (standing height (cm; Detecto, Webb City, MO, USA), body mass (kg; Detecto, Webb City, MO, USA), and three site skin fold thickness (males sites were pectoralis, abdominal, quad; female sites were triceps, oblique, quadriceps; mm; Lange skinfold caliper, Beta Technology, Santa Cruz CA, USA)), followed by the following normalized warm-up protocol: 5 minutes of static stretching; 5 minutes pedaling a cycle ergometer at 0.5 kilopond resistance and 55 revolutions per minute; one unloaded CMJ, with arm swing, at a perceived 50% effort; and two unloaded CMJ, with arm swing and maximal effort. Participants then completed the CMJ protocol which consisted of 10 maximal effort CMJs (five conditions with two maximal effort trials under each condition) with the participants self-selecting the depth of the countermovement. The CMJ conditions were performed in the following order, with two consecutive maximal effort trials, and a fixed arm position: 0kg; 5kg; 10kg; 15kg; and 20kg (Werksan IWF Certified Training Barbell, Werksan USA, Moorestown, NJ, USA). Participant's arms were fixed by holding a weightlifting bar in the high bar squat position (Schoenfeld, 2010). All jump conditions were executed by the participant stepping onto a mat which was on top of the force platform, followed by the prompt, "three, two, one, jump!" Sixty seconds of rest was required between jumps.

CMJ characteristics assessed for this work include peak jump height (cm) and average jump power per kg of body mass (Watts/kg). CMJ height was calculated using flight time measured from a force plate (Kistler 9260AA6 Portable Force Plate; 500mm x 600mm; sampling at1000Hz, Kistler, Amherst, NY, USA; Bioware 5.2 analysis software, Kistler, Amherst, NY, USA) and the following equation ($g = 9.81\ m/s^2$): CMJ height = $(gt^2)/8$. CMJ average power per kg of body mass collected using a linear position transducer (GymAware Power Tool LPT; 50Hz, ACT, Australia). All CMJ data was averaged between the two maximal efforts under each condition to give a more accurate representation of the individual's typical performance (Henry, 1967).

All statistical analyses were performed using SPSS software (SPSS version 22.0; IBM, New York, NY, USA). Separate 2(sex) x 5(load) repeated measures analyses of variance (RMAVONA) were used to evaluate any differences across the loading scheme within the genders for each variable (CMJ height and CMJ power/kg of body mass). If estimated sphericity was not verified (via Mauchly's W test) the Greenhouse-Geisser correction was applied. Initial statistical significance was set at an alpha level of $p \leq 0.05$, with any statistically significant interactions within the jumping conditions being identified using the pairwise comparisons.

RESULTS: Descriptive statistics for the RMANOVAs and all statistically significant interactions are provided in Table 1. The results reveal that lighter loads used while jumping provide higher powers per kg of body mass in both the males and females, with the differences being more pronounced and happening more often in the females. Additionally, lighter loads used during jumping also results in greater peak jump heights, which holds true across the loading scheme for both males and females.

DISCUSSION: The results from this research provide several talking points. First, the measures of scaled average power during jumps decrease more frequently in the females compared to males. Second, all jump heights were practically and significantly higher for all lighter loads when compared to all heavier loads. All of those results are what would be expected in this population. This is likely due to two underlying factors. First, this population is not highly trained. That is individuals who are not well trained will often have (sometimes precipitous) drops in vertical jump abilities/characteristics as loads are increased during CMJ efforts. Second, it is likely that the participants here were simply not strong enough, specifically the males. Ultimately, we would hope to see, as training status and experience increases, this drop off in CMJ characteristics lessen as adaptations are made (Kraska, et al. 2009).

However, practical trends in the data did show the scaled average power for females being the same or greater than the males at many of the loads. Continued research is warranted to expand this data set in the current and novel populations in an attempt to establish rationale for these trends.

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Table 1: CMJ Power Results

	RMANOVA Results	Jump Condition Differences	*p*	Condition Equated Values (Watts/kg; mean ± standard deviation)
Males	*p* = .008; ES = .355; 1-β = .827	5kg > 20kg	0.012	29.14 (±7.84) > 26.25 (±8.34)
Females	*p* = .000; ES = .309; 1-β = .976	0kg > 15kg	0.013	31.10 (±6.40) > 28.32 (±6.00)
		0kg > 20kg	0.008	31.10 (±6.40) > 26.70 (±6.31)
		5kg > 20kg	0.003	29.33 (±6.29) > 26.70 (±6.31)
		10kg > 20kg	0.033	28.82 (±6.90) > 26.70 (±6.31)

CMJ Height Results

	RMANOVA Results	Jump Condition Differences	*p*	Condition Equated Values (cm; mean ± standard deviation)
Males	*p* = .000; ES = .830; 1-β = 1.000	0kg > 10kg	0.001	34.53 (±6.01) > 30.40 (±6.04)
		0kg > 15kg	0.000	34.53 (±6.01) > 29.15 (±5.71)
		0kg > 20kg	0.000	34.53 (±6.01) > 27.21 (±5.41)
		5kg > 10kg	0.000	33.98 (±5.92) > 30.40 (±6.04)
		5kg > 15kg	0.000	33.98 (±5.92) > 29.15 (±5.71)
		5kg > 20kg	0.000	33.98 (±5.92) > 27.21 (±5.41)
		10kg > 15kg	0.033	30.40 (±6.04) > 29.15 (±5.71)
		10kg > 20kg	0.000	30.40 (±6.04) > 27.21 (±5.41)
		15kg > 20kg	0.010	29.15 (±5.71) > 27.21 (±5.41)
Females	*p* = .000; ES = .898; 1-β = 1.000	0kg > 5kg	0.000	23.27 (±4.96) > 21.59 (±4.56)
		0kg > 10kg	0.000	23.27 (±4.96) > 18.66 (±4.52)
		0kg > 15kg	0.000	23.27 (±4.96) > 17.55 (±4.62)
		0kg > 20kg	0.000	23.27 (±4.96) > 15.17 (±4.12)
		5kg > 10kg	0.000	21.59 (±4.56) > 18.66 (±4.52)
		5kg > 15kg	0.000	21.59 (±4.56) > 17.55 (±4.62)
		5kg > 20kg	0.000	21.59 (±4.56) > 15.17 (±4.12)
		10kg > 15kg	0.002	18.66 (±4.52) > 17.55 (±4.62)

	10kg > 20kg	0.000	18.66 (±4.52) > 15.17 (±4.12)
	15kg > 20kg	0.000	17.55 (±4.62) > 15.17 (±4.12)