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Comparison of Propulsive Power During Loaded Countermovement Jumps Performed in Water  
versus Land in College Aged Males

By

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A Plan B Project submitted in partial fulfillment  
of the requirements for the degree  
of

Master of Science in Health and Human Movement

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2015

## Abstract

As use of an aquatic environment increases as a training and rehabilitative tool, the purpose of this study was to assess peak propulsive power in loaded countermovement jumps (CMJ) in water and compare them to loaded CMJ on land. 20 college aged ( $24.6 \pm 3.6$  years) recreationally active males performed 4 randomized countermovement jumps on a force plate with increasing loads (bodyweight [BW], BW+10%, BW+20%, BW+30%) in two environments: immersed in water at the xiphoid process and on land. Peak power (PP) and mean power (MP) normalized to apparent mass were assessed for all jumps. A 2 (environment) by 4 (load) repeated measures ANOVA was used to determine main effects and the interaction. PP was greater in the water for all loading conditions compared to land ( $13.1 \pm 3.4$ ,  $12.3 \pm 3.6$ ,  $10.4 \pm 3.4$ ,  $9.9 \pm 3.1$  kW vs  $5.8 \pm 1.4$ ,  $5.7 \pm 1.4$ ,  $5.8 \pm 1.4$ ,  $5.9 \pm 1.4$  kW) for the BW, BW+10%, BW+20% and BW+30% conditions, respectively. The same trend and magnitude differences were identified for MP ( $5.5 \pm 1.7$ ,  $5.2 \pm 2$ ,  $4.4 \pm 1.5$ ,  $4.1 \pm 1.6$  kW vs  $2.6 \pm 0.8$ ,  $2.4 \pm 0.8$ ,  $2.5 \pm 0.8$ ,  $2.5 \pm 0.7$  kW) for water vs land, respectively. The trend for decrease in PP and MP in water was significant while there were no significant trends for decreases in PP and MP on land. These results suggest loading BW on land in the range of 10-30% essentially has no detrimental impact on PP and MP measures yet creates a significant reduction when performed in water. Potential decreases in force production and/or movement velocities during takeoff may account for these observed differences due to environment. Further research could identify these differences and provide valuable insights for strength and conditioning professionals to use an aquatic environment to complement traditional land-based training.

## Introduction

Peak propulsive power (PP) has been identified as a determinant of athletic performance and training to develop peak power has become common practice in professional and amateur sport (Cronin & Sleivert, 2005; Haff & Nimphius, 2012; Hansen, Cronin, Pickering & Douglas, 2011; Kawamori & Haff, 2004). A countermovement jump (CMJ) has been established as an valid and reliable measure of PP (Markovic, Dizdar, Jukic & Cardinale, 2004; Sheppard Cormack, Taylor, McGuigan, & Newton 2008). Performance of CMJs on land under progressive loading produces a power curve displaying peak power and the decline of PP as the load increases (Haff & Nimphius, 2012; Kawamori & Haff, 2004; Sheppard et al., 2008; Stone et al, 2003). As the popularity of an aquatic environment increases as a training and rehabilitative tool, the purpose of this study was to compare the power curve created by performing incrementally loaded CMJs in water and on land.

Power is the product of force (Newtons) and velocity (meters/seconds) (Haff & Nimphius, 2012; Cronin & Sleivert, 2005). A maximum height CMJ has been established as a reliable and valid measure of explosive power in the lower limbs (Markovic et al., 2004; Sheppard et al., 2008) and correlates with sprint performance (Cronin & Hansen, 2005; Peterson, Alvar, Rhea, 2006). PP typically occurs at compromised levels of both force and velocity (Kawamori & Haff, 2004). The amount of resistance necessary to obtain PP during performance of an explosive movement such as a CMJ or squat jump (SJ) varies among individuals and can occur in a range from 30% to 60% of 1 repetition maximum (1RM) back squat (Baker, Nance, Moore, 2011; Cronin & Sleivert, 2005). Stone et al. (2003) measured the PP output of 22 male subjects performing both a counter-movement and static squat jump at 10-100% 1RM for each movement. The greatest PP value was at 10% 1RM and decreased as load increased for both

movements. The 5 participants with the greatest 1RMs in this study produced their greatest PP outputs at 40% 1RM while the 5 participants with the lowest 1RMs produced their greatest PP at 10% 1RM in both movements. When trained strength and power athletes (elite rugby players) performed loaded squat jumps, PP occurred between 55% and 59% of 1RM back squat (Baker et al., 2011), but these values were not statistically different from 48-63% of 1RM back squat. Consistent with these findings Cormie, McCaulley, Triplett, & McBride (2007) reported PP of 1RM back squat occurred at 56% 1RM, but was not significantly different from other loading intensities. Cormie et al. (2007) also reported different percentages of 1RM based on the exercise performed: PP in the jump squat occurred at 0% 1RM, and PP in the power clean occurred at 80% 1RM. Taylor & Taylor (2014) reported the decline of PP (3.4kW, 3.2kW, 2.9kW, 2.6kW, 2.6 kW) as load (BW, 10%, 20% 30%, 40%, 50% BW) increased in 6 college age male hockey players who performed CMJ under incremental loading. Despite the distinct trend of decreasing PP, no statistical significance was reported.

Variance in identifying PP depends on the training status of subjects, the exercise measured, and the testing protocol used. Each individual will produce a power curve specific to their skill and training status. Regardless of the point at which PP occurs, mechanical power produced by performance of CMJ or SJ under progressive loading decreases incrementally from PP to a point where concentric force is no longer sufficient to overcome resistance (Kawamori & Haff, 2004; Peterson et al., 2006). PP must be assessed under a range of loads to determine PP for each individual (Cronin & Sleivert, 2005). Principles of specificity dictate training to enhance PP must occur at the force and velocity required to produce peak power (Behm & Sale, 1993; Cronin & Sleivert, 2005; Kawamori & Haff, 2004).

Properties of fluid drag and buoyancy acting on an individual in shallow water create a unique environment for athletic training and rehabilitation. Reported measurements of ground reaction forces (GRF) and impact forces, when normalized to apparent mass, display increased GRF and decreased impact forces when performing a CMJ in water compared to a CMJ on land (Colado et al, 2009; Donoghue, Shimojo, & Takagi, 201; Louder, Searle, Bressel, 2015; Triplett et al. 2000). Fluid drag requires the jumper to exert greater force against additional resistance created by the water to leave the support surface (Arazi & Asadi, 2011; Colado et al., 2009; Louder et al., 2015; Miller et al. 2002; Ploeg et al., 2010). Buoyancy reduces apparent mass in the water creating decreased impact forces and softer landings in the water (Arazi & Asadi, 2011; Miller et al., 2007; Robinson, Devor, Merrick, Buckworth, 2004). Drag force requires an individual jumping to produce greater concentric force to overcome the effects of increased viscosity in the water in order to leave the surface they stand on, yet the individual will be spared the impact forces associated with equivalent concentric GRF produced on land. Previous research from our laboratory has reported significantly greater PP values in the water compared to on land when normalized to apparent body weight (Louder et al., 2015).

Evidence supporting the influence of buoyancy and fluid drag in aquatic training programs has grown in the past 10-15 years. Increased force production during the concentric phase and decreased impact forces during the landing of a single leg jump were observed by Triplett et al. (2009) in water compared to on land when they assessed 12 female handball players. Robinson et al. (2004) reported that a cohort of recreationally active women who participated in an aquatic plyometric training program displayed improved power, torque, sprint velocity, and reduced muscle soreness at the end of eight weeks compared to a similar cohort who performed the same plyometric training program on land. Miller et al. (2002) reported 40N

improvements in muscle power during a CMJ after completion of an eight week aquatic plyometric training program. The authors also reported a similar plyometric program performed on land had an average of 18N improvement in muscle power during a CMJ but neither group (land or water) displayed significant improvements in vertical jump.

Others have reported no significant differences between land based and aquatic based training programs (Miller et al. 2007; Ploeg et al., 2010; Stem & Jacobson 2007). Arazi and Asadi (2011) reported at the end of an eight-week plyometric program, during which one group of young male basketball players trained in the water and another group trained on land, both groups showed significantly improved sprint times (36.5m and 60m) from baseline to post testing with no significant differences between treatment groups (land vs. water). The aquatic training group also showed significant differences in increased leg strength when compared with the control group, but no significant differences when compared to the land training group. White and Smith (1999) also reported increased muscle strength at the end of an eight week aquatic training program. Arazi, Coetzee, and Asadi (2012) repeated a study similar to Arazi & Asadi (2011) and reported similar outcomes- the aquatic and land trained groups displayed similar improvements in anaerobic power. The results of these studies imply aquatic based plyometric programs are at least equal to land based plyometric programs.

In order to extend present understanding of using an aquatic environment for plyometric exercises, the primary purpose of this study was to compare peak propulsive power produced by performing body weight and loaded CMJ in the water versus on land. This study will be a means of improving understanding of an aquatic environment as a training and rehabilitative tool.

This study will have three hypotheses; 1) PP and MP will incrementally decrease as load increases; 2) PP and MP in the water will be greater than PP and MP on land; 3) There will be an interaction between condition and load.

### **Methods**

Twenty apparently healthy young adult men aged 18-35 years (see Table 1) were recruited from the university campus and surrounding community through personal contact by the investigator and word of mouth. In order to participate, subjects reported they were: 1) free from any orthopedic injury, have not had recent (within 3 months) surgeries preventing them from safely completing countermovement jumps with loads; 2) were recreationally active. Subjects were appraised of the general requirements of the study and given a letter of informed consent to read and sign. All procedures including the informed consent form were approved by the Institutional Review Board (IRB# 4967 Amendent #2).

### **Procedures**

Subjects performed three randomized countermovement jumps (CMJ) at each of 8 conditions, totaling 24 CMJs. Conditions consisted of two environments (land vs water) and 4 loads (unloaded, 10% , 20%, and 30% bodyweight [BW]) in each environment. The BW condition was an unloaded condition. The 10%, 20%, and 30% were percentages of body mass measured on land and added to each subject for performance of weighted CMJ during loaded conditions.

All jumps were performed on a waterproof force plate (AMTI, Model OR6-WP; Columbus, OH) positioned on the floor of an adjustable-height underwater treadmill (Hydroworx 2000; Middletown, PA). Subjects were allowed to warm up prior to testing by performing air squats and several CMJs. Subjects apparent mass was measured with the force plate. Water

immersion level for CMJ was set to the xiphoid process. Subjects were instructed to keep their hands on their hips and to, “jump as high as possible using your natural jumping method.” The CMJ involved rapid hip flexion, knee flexion, and dorsiflexion immediately prior to the concentric phase of the jump to utilize the stretch shortening cycle. Depth of countermovement was self-selected.

Loading was accomplished by use of a weighted vest (MIR Vest Inc. San Jose, CA). Weight of the load was rounded to the 1.4 kg (3 pounds) increment nearest to the percentage of bodyweight required by each condition. Loading did not exceed 27.2 kg (60 pounds), which was the maximum capacity of the vest. A rest of 2-3 minutes duration occurred between conditions as the vest was removed, the load adjusted, and the vest again secured to the subject.

An acceptable trial was completed when the subject performed a CMJ, kept their hands on their hips throughout the jump and landed with both feet simultaneously on the force platform. Jumps failing to meet this criteria were to be repeated.

### **Data Collection**

Data collection was triggered manually and recorded using Netforce software (AMTI; Columbus, OH), at a duration of 10s (1000 Hz sampling rate with a 25 N Threshold). Data sampling began approximately 3 seconds prior to the subject initiating the CMJ. Vertical ground reaction force (GRF) (N) values measured by the force plate were saved as raw data.

### **Peak Power and Mean Power**

The GRF of the propulsive phase of each CMJ was imported into Microsoft Excel (Microsoft Corp., Redmond, WA) along with the apparent mass of each subject. The propulsive phase was defined as all GRF values above apparent mass during the propulsive phase of the

jump (Hori et al. 2009; Louder, Searle, Bressel, 2015). The following equations were used to calculate power at each time point (Louder, Searle, Bressel, 2015):

$$\text{Eq. 1. } (\text{Force})(\text{time})/\text{apparent mass} = (\text{acceleration})(\text{time})$$

$$\text{Eq. 2. } \int(\text{acceleration})(\text{time}) = \Delta\text{velocity}$$

$$\text{Eq. 3. } \text{Power}_t = (\text{force}_t)(\Delta\text{velocity}_t) = (\text{force}_t) \int_0^t [(\text{acceleration})(\text{time})]$$

Peak propulsive power was the highest power value obtained from this calculation while mean power was the average of all the power values during the propulsive phase.

### **Data Analysis**

The average of the three jumps for PP and MP were used for data analysis. Independent variables were: environment (land or water) and load (BW, 10%, 20%, 30%). Dependent variables were peak propulsive power (PP) and mean propulsive power (MP). A two (environment: land vs water) by four (load: 0, 10, 20, 30% BW) repeated measures ANOVA (SPSS 22, Chicago IL.) was used to determine if significant main effects and interactions were present. In the case of a significant interaction LSD post-hoc tests determined the location of significance between conditions. The level of confidence was set at  $p < 0.05$ .

## **Results**

### **Peak Power**

#### *Environment*

There was a significant main effect for environment on PP, ( $F_{7,133} = 138.1$ ,  $\eta^2 = 0.88$ ,  $p < 0.001$ , see Table 3). Results of the one-way ANOVA and LSD post-test showed PP in water was significantly greater than PP on land in all conditions ( $p < 0.001$ ).

#### *Load\*Environment*

There was a significant interaction between load and environment on PP, ( $F_{7,133} = 28.0$ ,  $\eta^2 = 0.60$ ,  $p < 0.001$ , see Figure 1). The interaction between load and environment resulted in a trend of decreasing PP values as load increased, a trend which was not observed in the land condition.

The following regression equation (Eq. 4) was obtained using simple linear regression for PP in the water:

$$\text{Eq. 4. } PP_{\text{water}} = -1120.9(\text{Load}) + 14229.0$$

A significant regression for PP on land was not found ( $R^2 = .001$ ,  $F_{79} = .09$ ,  $p = 0.76$ ).

## **Mean Power**

### *Environment*

There was a significant main effect for environment on MP ( $F_{7,133} = 100.7$ ,  $\eta^2 = 0.84$ ,  $p < 0.001$ , see Table 2). MP was found to be significantly greater in the water compared to on land ( $p < 0.001$ ).

### *Load\*Environment*

There was a significant interaction between load and environment on MP ( $F_{7,133} = 20.67$ ,  $\eta^2 = .52$ ,  $p < 0.001$ , see Figure 2). The interaction between load and environment resulted in a trend of decreasing MP values as load increased, a trend which was not observed in the land conditions.

The following regression equation (Eq. 5) was obtained using simple linear regression for MP in the water:

$$\text{Eq. 5. } MP_{\text{water}} = -475.0(\text{Load}) + 6003.7$$

Load in Eq. 5 represents the percentage of weight relative to BW added to the body and is expressed in whole numbers (10% of BW added to a participant would be expressed as 1).

Results of the regression indicate load explained 9% of the variance in MP ( $R^2=.09$ ,  $F_{79}=7.8$ ,  $p=0.007$ , see Figure 2). Load significantly predicted MP ( $\beta=6003.7$ ,  $p=0.007$ ). A significant regression for MP on land was not found ( $R^2=.001$ ,  $F_{79}=.09$ ,  $p=0.76$ ).

### **Discussion**

The purpose of this study was to compare the influence of conditions (land vs. water) on incrementally loaded CMJ. This study had three hypotheses: 1) PP and MP will significantly and incrementally decrease as load increases; 2) PP and MP in the water will be significantly greater than PP and MP on land; and 3) There will be a significant interaction between conditions and load. Results of the analyses generally support all three hypotheses.

Differences in PP and MP were identified between most but not all loading conditions. These findings are consistent with other reports of incrementally loaded CMJ (Taylor & Taylor, 2014; Sheppard et al. 2008). PP values in this study for the BW water and BW land condition ( $13.1\pm 3.4$  kW and  $5.8\pm 1.4$  kW respectively) were consistent with those reported by Louder et al. (2015) ( $11.0\pm 5.1$  kW and  $5.8\pm 1.3$  kW) who tested a similar population and used the same data system and collection method. Decreases in PP in the water occurred at a rate greater than that at which PP decreased on land.

On land PP and MP did not decrease as load increased. Taylor & Taylor (2014) reported a decreasing PP trend as load increased when six males (21 years old) performed CMJ unloaded and with 10%, 20%, 30%, and 50% BW across their shoulders. Peak velocity also decreased as the load increased. Sheppard et al. (2008) tested 26 (19.8 years old) power trained subjects who performed CMJ under 3 loading conditions: unloaded, BW+25%, and BW+50%. They reported a difference in PP of .3kW between unloaded and BW+25% conditions. The difference in PP between the BW and BW+50% condition was .8kW. Despite these differences, neither Taylor &

Taylor (2014) or Sheppard et al. (2008) reported statistical analysis of their data. For the population tested in this study, the addition of 10%, 20%, and 30% load may not have been sufficient on land to decrease the velocity of the CMJ to impair PP. Driss et al. (2010) observed similar findings when trained subjects performed loaded static squat jumps. 20 trained jumpers and 20 sedentary individuals performed static squat jumps on land. The loading conditions were: BW, BW+5kg, BW+10kg. The 5kg loaded represented a 7% BW increase and the 10kg load a 14% BW increase. Trained jumpers had no significant decrements to PP under either load while the sedentary individuals did have significant decrements to PP as load increased. Driss et al. (2010) suggest PP is independent of load and dependent on velocity of movement; small increases in load were not sufficient to decrease velocity in a way that effected PP. Subjects tested in this study have only trained on land. They have been exposed to a range of forces and velocities typical for training on land but are naive to the decreased forces and increased velocities in water. The decline of PP in water as load increased, which was not observed on land, suggests there is a training gap which can be filled by performing loaded countermovement jumps in water. This will expose participants to a range of forces and velocities unavailable when land training.

PP and MP were significantly greater in the water than on land. This is consistent with previous research (Louder et al., 2015). Kinetic differences between performing CMJ in the water and on land are influenced by the presence of buoyant forces in water and drag in the water. Buoyant force increases concentric GRF, impulse, and PP in the water when normalized to apparent mass and compared to land (Louder et al. 2015; Searle, Louder, Bressel, 2015). Properties of buoyant forces result in: reduced apparent mass, shorter time to stability (TTS) (Searle et al., 2015), and a shorter amortization phase when subjects transition from an eccentric

to concentric muscle action (Miller et al. 2002). This increases the velocity of plyometric type countermovements in the water. Increased PP and MP may be the result of increased velocity when measuring the kinetics of plyometric type movements in shallow water.

A significant interaction occurred between water and land. In the aquatic environment greater PP and MP was observed compared to land, and significant decrements in PP and MP were observed in the water which were not observed on land. Both PP and MP for the water conditions had significant (PP  $p=0.001$ , MP  $p=0.007$ ) regression equations describing 12.4% and 9.0% of variance respectively. The regression equation for PP suggests an individual performing a CMJ from a position immersed in water at the xiphoid process and loaded with 60% of their body weight (which apparent mass would be equal to actual BW on land) would produce a similar PP to an unloaded CMJ on land. This supports the theory buoyant forces are responsible for decreased apparent mass and increased PP in the water compared to land.

This study addresses the effects of loading and water submersion at the xiphoid process on peak power output from CMJ and adds to existing literature supporting aquatic training. It can be stated PP generated in the water is greater than that on land. And the power curve generated in water is similar to that reported in literature (Driss et al., 2010, Sheppard et al. 2008, Taylor & Taylor, 2014). Several training studies have already shown plyometric type training in an aquatic environment can result in similar improvements in athletic performance as seen on land (Arazi & Asadi, 2002; Arazi, Coetzee, Asadi, 2007; Miller et al., 2002; Robinson et al., 2004; Stem & Jacobson, 2007). These studies suggest the primary benefit to training in the water may not be greater performance compared to training on land but decreased injury risk and muscle soreness. A combined training program of performing plyometric exercises in the water and on land may have a velocity training effect. There may be a performance benefit to training at greater

velocities of movement in the water and at slightly slower velocities on land. These factors suggest healthy young populations may benefit the most by using aquatic training as a supplement to land based training.

There are several limitations to this study. Allowing subjects to self-select the depth of their countermovement is one limitation. Standardized instructions to “jump as high as possible” gave subjects the best opportunity to jump naturally but allowed for variance in countermovement depth between subjects. Self-selected counter-movement depth could have also resulted in with-in subject differences. Subjects had no familiarization to performing CMJ in the water. Often a subject’s head would become submerged in water during the countermovement phase, this may have caused subjects to alter their jumping strategy in an effort to keep their face out of the water. Use of the weighted vest could be a limitation to this study. The vest added area to subjects torso thereby increasing drag force as they propelled themselves out of the water. Other studies measuring mechanical power in CMJ and squat jumps used a barbell positioned across the shoulders (Baker et al., 2001; Cormie et al. 2007; Cronin & Hansen, 2005; Hansen et al., 2011; Taylor & Taylor, 2014; Sheppard et al., 2008, Stone et al., 2003), varying position and distribution of the load may effect kinetic or kinematic differences in jumping.

Future research could include analysis of rate of force development (RFD) and rate of PP development (RPPD) obtained from incremental loading of CMJ or other plyometric exercises in water. Assessing kinematic differences between plyometric exercises performed in the water and on land could also add to current understanding of the effects of aquatic training on performance variables. An aquatic based power training study may result in greater performance gains compared to aquatic based plyometric training. Increasing concentric force and velocity across

the entire force-velocity curve is the focus of mechanical power training (Haff & Nimphius 2012; Kawomori & Haff, 2004). Plyometric training seeks to develop the elastic properties of tissue which allow for utilization of stored energy from the stretch shortening cycle in consecutive movements. A rapid amortization phase developed through plyometric training is critical to power training, but only one aspect of power training. Aquatic studies seeking to improve mechanical power variables on land should train for mechanical power, not just plyometrics.

### **Practical Application**

These findings provide preliminary evidence that an aquatic environment may provide a stimulus for PP and MP production that challenges subjects in a loading range not observed while these exercises are performed on land. Therefore the strength and conditioning specialists may have a novel approach for working with clients to enhance PP and MP to eliminate the existing drop in PP and MP with novice exposure to water. If this deficit could be eliminated the real potential benefit might be to determine if there is a transfer effect to land-based plyometric performance.

### **Conclusion**

Performing incrementally loaded CMJ in water resulted in greater PP and MP than on land. Incrementally loaded CMJ in the water produced a power curve similar to the power curve reported in literature for incremental load profiles on land. Greater PP and MP in water compared to on land may have been the result of decreased apparent mass caused by the buoyant properties of water.

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Table 1.  
Descriptive Data of 20 Male Subjects

	Mean±SD
Age (years)	24.6±3.6
Height (cm)	180.5±6.8
Mass (Kg)	76.9±7.6

Table 2.

Mean ( $\pm$  SD) Apparent Mass and Percentage of Land BW per Condition.

Condition	Apparent Mass (kg)	Percentage of Land BW(%)
Water BW	24.8 $\pm$ 3.4	32.3 $\pm$ 3.9
Water 10%	33.4 $\pm$ 4.1	43.5 $\pm$ 4.1
Water 20%	40.3 $\pm$ 4.1	52.5 $\pm$ 3.8
Water 30%	46.5 $\pm$ 4.8	60.5 $\pm$ 3.8
Land BW	76.9 $\pm$ 7.6	100
Land 10%	85.4 $\pm$ 8.7	111.1 $\pm$ 1.7
Land 20%	90.6 $\pm$ 9.5	120.0 $\pm$ 2.6
Land 30%	100 $\pm$ 10.6	130.2 $\pm$ 2.5

Table 3.

Absolute Peak Power and Mean Power in Water and on Land in kW.

	PP Water (kW)*	PP Land (kW)	MP Water (kW)*	MP Land (kW)
BW	13.1±3.4	5.8±1.4	5.5±1.7	2.6±0.8
10%	12.3±3.6	5.7±1.4	5.2±2.0	2.4±0.8
20%	10.4±3.4	5.8±1.4	4.4±1.5	2.5±0.8
30%	9.9±3.1	5.9±1.4	4.1±1.6	2.5±.7

\*Significantly greater than land for all loads ( $p<0.001$ ).

Table 4.

Means for relative Peak Power and Mean Power in the Water and on Land in W/kg

	PP Water (W/kg)*	PP Land (W/kg)	MP Water (W/kg)*	MP Land (W/kg)
BW	168.4±7.7	74.2±2.5	70.4±4.1	33.0±1.7
10%	157.9±7.8	73.7±2.6	67.2±4.5	31.4±1.7
20%	134.1±8.0	75.0±2.6	56.3±3.5	32.0±1.8
30%	127.7±7.2	75.7±2.6	53.5±3.7	32.0±1.6

\*Significantly greater than land for all loads ( $p<0.001$ ).

Mean±SD

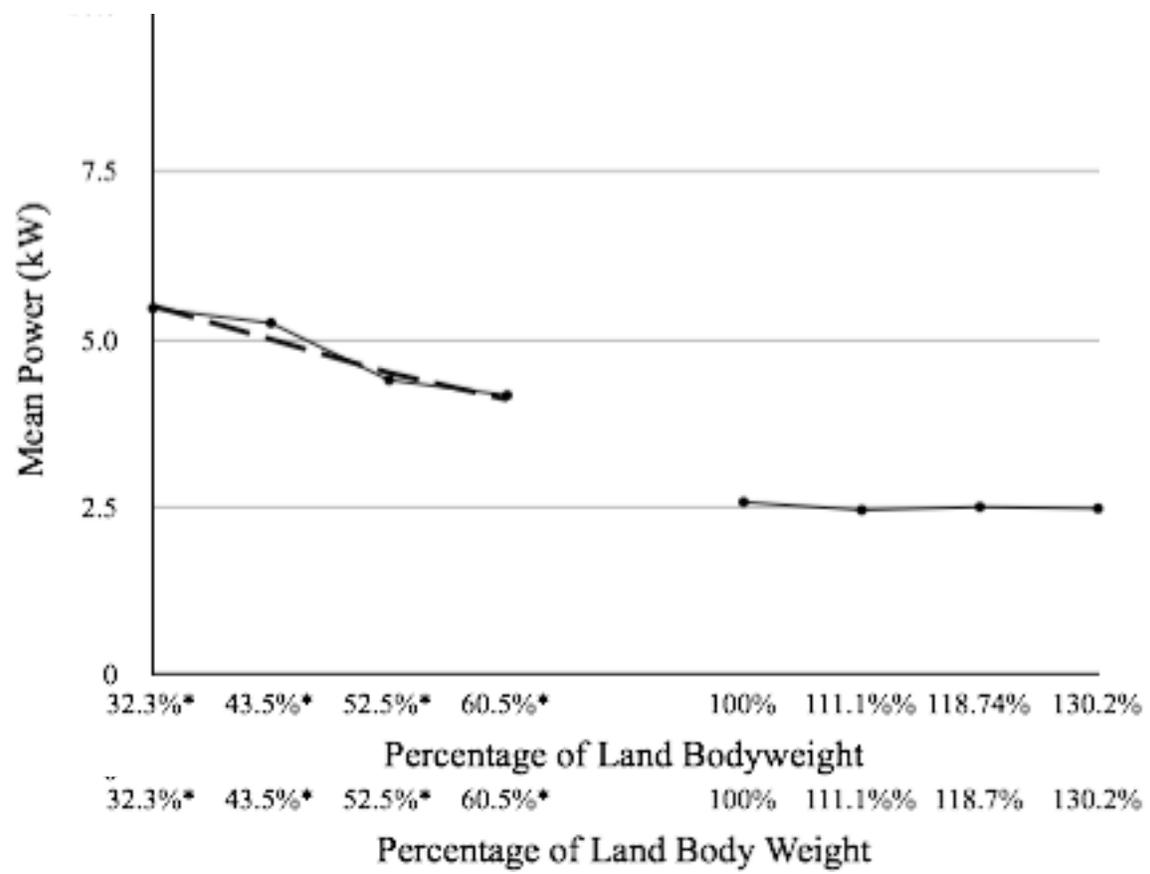


Figure 1. Peak Power in Water and on Land. W\_ denotes water environment, L\_ denotes land environment. \*Significantly greater than land ( $p < 0.001$ ).

Figure 2. Mean Power in Water and on Land. W\_ denotes water environment, L\_ denotes land environment. \*Significantly greater than Land ( $p < 0.001$ ).