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THE INFLUENCE OF STRENGTH AND POWER ON ROWING, SKI ERGOMETER PERFORMANCE

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ABSTRACT

Ergometers have been developed as off-season or dryland training tools for sports such as rowing and cross-country skiing. These ergometers have recently been staples in the training methods for functional fitness athletes. Purpose: To examine the relationship between athlete strength and power with rowing ergometer and ski ergometer performance. Methods: Eight healthy college-aged participants, age 18-26 years volunteered to go through a series of strength and ergometric exercises while being assessed with a metabolic cart to measure gas exchange. The three strength measures were a maximal effort on bench press, back squat, and deadlift. A watt bike was also used to assess lower body power output. All strength tests were performed following the National Strength and Conditioning Association protocols. The ergometric performances on ski ergometer and rower were performed both using the Concept2 model with the damper settings at 10. Results: A significant relationship exists between strength and ergometer performance at both sprint and mid-distances. Conclusions: Athlete strength is a significant contributor to ski ergometer and rowing ergometer performance at 100-meter and 2000-meter performances. When considering training protocols for rowing and cross-country skiing, athletes and coaches should invest in addressing strength as a meaningful portion of the training effort.

Contribution/Originality: The paper's primary contribution is finding the relationship athlete strength and power have with ergometer performance.

1. INTRODUCTION

Rowing is one of the most challenging sports due to its simultaneous aerobic and anaerobic requirements (Dvorak *et al.*, 2013). Rowing, whether for sport or fitness, represents one of the most challenging exercises in fitness, because it is associated with both aerobic and anaerobic challenge (Mäestu *et al.*, 2005). The physiological demands of cross-country skiing require competitive skiers to have high maximal oxygen uptakes and anaerobic thresholds. Anaerobic capacity has a relatively less important role but may be of greater importance today with the faster race velocities resulting from the new skiing techniques of ski skating (Holmberg, 2015).

Ergometers are primarily designed to simulate biomechanical movements and physiological stresses associated with a specific sport, allowing exercise to be performed in an indoor environment (De Luca, 1997). However, ergometer training has become a prevalent method of both anaerobic and aerobic training (Podstawski *et al.*, 2014). The safety and ease of use has resulted in increased interest in this mode of exercise training. Exercises such as cycle ergometry, provide individuals with alternative methods of training that assist in the achievement of similar physiological improvements without the weight-bearing activity (Bouaziz *et al.*, 2015). This form of exercise can be added into training regimens to alleviate joint impact and decrease the risk of injury during training.

As with most physical activity the physiological benefits outweigh the risks. Training regimens should consider both aerobic and anaerobic systems while also taking into account sport-specific strength development. It is crucial that training is broad-based in order to establish greater muscular strength and power while also encompassing both cardiovascular and muscular endurance (Jabbour *et al.*, 2015).

The variety in a training program dictates the athlete's general physical preparedness. Improving anaerobic and aerobic capacity will allow the athlete to excel in all aspects of performance as opposed to suffering from training decrements (Haddock *et al.*, 2016). The improvement of the anaerobic threshold in skiers and rowers is linked to the nature of their training regimens. The use of a ski ergometer in training leads to improvements in oxidative capacity and increase in cardiorespiratory transport.

Our study examined the relationship between strength, power and ergometer performance. As commonly prescribed methods of developing fitness and competition very little assessment as to what lends to successful performance has been conducted.

Consistent with the work conducted by Mäestu *et al.* (2005) the idea that a combination of physiological variables could predict performance better than either individual variables or one category of variables for an athlete's performance on anyone or all pieces of equipment. Through the identification of the relationship between anthropometric, physiological, strength and power measures with athlete performance on this equipment an educated prediction can be made to assist athletic trainers, coaches and others in the development of programs designed to enhance an athlete's performance and decrease the likelihood of injury.

2. METHODS

2.1. Subjects

Subjects were 8 recreational athletes (5 males, 3 females, ages 18–26) from the Aiken, SC community Table 1. The participants had to be free of injury and capable of performing the different functional tests. All subjects reviewed and signed an informed consent statement which explained the numerous tests that were to be performed before data collection occurred.

Table-1. Anthropomorphic and Performance Results

Variable	All (N=8)	Female (n=3)	Male (n =5)
Age (y)			
Height (cm)	173.20 ±9.20	164.26 ±7.34	178.2 ±3.70
Weight (kg)	74.18 ±10.80	72.21 ±13.58	75.36 ±10.35
VO2Max	46.39 ±9.23	39.37 ±2.06	50.60 ±9.36
Body Composition	19.35 ±9.92	29.53 ±5.31	13.24 ±5.79
Bench Press	199.29	118.33 ±20.82	260.00 ±31.09
Back Squat	287.14 ±97.20	193.33 ±10.41	357.5 ±58.52
Deadlift	343.57 ±126.	221.67 ±45.09	435.00 ±67.82
Lower Body Power	987.71 ±277.82	734.67 ±107.86	117.50 ±185.89
Values expressed as mean ± SD			

Source: Values expressed as mean ± standard deviation (SD)

Table-2. Statistically Significant Relationships between Participant Characteristics and Performance.

Variable	Significance	R value
Bench Press to 100m Row	0.03	0.93
Dead Lift to 2000m Row	0.01	0.9
Lower Body Power to 2000m Row	0.03	0.91
Body Composition to VO2Max	0.01	0.87
Body Composition to 2000m Row	0.02	0.93
Bench Press to Lower Body Power	0,01	0.92
Back Squat to Lower Body Power	0.01	0.89
Deadlift to Lower Body Power	0.01	0.95
Body Composition to Lower Body Power	0.02	0.85
Level of significance set at $p \leq 0.05$		

Source: Statistical significance: p= $\leq$0.05

2.2. Data Collection

To assess the influence an athlete's anthropomorphic, physiological, strength and power variables have on rowing and ski ergometer performance no less than 8 participants were recruited to join this study. All participants were recreationally trained, healthy, asymptomatic and college aged (18-26yrs). Before data collection occurred, a request for Human Subjects approval was obtained from the University of South Carolina Institutional Review Board and complied with all rules, regulations, and training requirements**.** Prior to any tests performed, participants were given a copy of the informed consent and a detailed outline of what they would be asked to do throughout the study. Participants had their height, weight, hip-to-waist ratio and body composition assessed prior to engaging in any additional measures. To determine strength the participants were asked to complete a one-repetition maximal load (1RM) assessment for bench press, back squat and deadlift movements. All strength measures were performed under the protocols of the NSCA to provide consistency and safety for the participants throughout the study. Power was assessed through a three 6 second all-out effort on a Watt bike to for lower body power and a medicine ball shot to assess upper body power. Upon completion of these assessments the participants then completed a series of efforts on the rowing ergometer and ski ergometer. One effort consisted of three trials on a 100-meter piece and the second effort consisted of a 2000-meter piece, accounting for six (6) total efforts. Each participant completed all the tests within a two-week time frame to allow full recovery between each of the tests in order to establish true maximal output measurement was recorded. During these performance efforts, the percentage of maximal metabolic effort was also assessed. These distances are standard measures for performance. All data collection occurred in the Fitness Performance Laboratory at the University of South Carolina Aiken. The proposed experiment was designed to assess the metabolic demand of a rowing ergometer and ski ergometer as well as to assess various strength variables to determine the relationships these might have to performance.

3. DISCUSSION

Descriptive statistics on all variables were calculated in an effort to develop a global perspective of the participants. Pearson product-moment correlations were performed to determine if a statistically significant relationship existed between the performance variables and all other variables of interest. All statistics were calculated using SPSS 24.0. The aim of this study was to determine if a significant relationship between strength and ergometer performance exists. A pooled sample of both female and male participants was used for statistical analysis due to a limited sample size for each respective group. Results revealed that there was strong evidence that lower body power and strength influence ergometer performance at both short and mid-distances. There were statistically significant similarities between not only the strength measures and the ergometer performances but also between metabolic measures for row and ski erg efforts. This research indicated that strength (bench press, back squat and deadlift) and the 100-meter ergometer efforts had a higher statistical relationship overall. The 100-meter efforts are sprints in the truest sense, therefore they can be performed successfully with a strength bias. Longer distance efforts (2000-meters) on the ski ergometer and rowing ergometer required similar metabolic demands (%VO_{2max}). Participants worked up to metabolic readings very close to their VO2 max test which showed that the effort output was truly maximal and their times reflected each athletes' peak performance.

When considering dry land or offseason training for sports such as cross-country skiing or rowing, athletes should include movements designed to enhance their overall strength and ability to produce power. As strength and conditioning recommendations are developed significant attention should be offered to the development of the athlete in a holistic perspective with a slight bias to the respective sport performance. This general physical preparedness with a lean toward specific sport performance may yield better performance.

Strength and power have a significant relationship with ergometer performance at short and middle distances. Maximal volume of oxygen was also revealed as a significant contributor to ergometer performance. The findings of this study may be applied to establishing training protocols for rowing and cross-country skiing athletes. Future research may consider using varied distances (500, 5000, 10000-meters) to determine the relationship between strength and power measures with ergometer performance.

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