Classifying Isometric Strength Characteristics with Static and Countermovement Jumps Amongst Various NCAA Division I Teams

Joshua H. Gibson[1], Kyle G. Rochau[1], Hannah B. Swirple[1], Lauren E. White[1], Jarrod D. Burton[1], Andrew Layne[1], W. Guy Hornsby[1]

[1]West Virginia University, Morgantown, WV

Introduction

For thousands of years, resistance exercise has seen its place in the lives of many, starting around the ancient Olympic games in 776 BCE, complementing the training of wrestlers, gladiators, boxers, and others involved with various physical pursuits (Kramer, 2017). The ability to act on or resist being acted on by an object is paramount in sport, often a key determinant of victory or defeat. Within athletics, force production often occupies single, minimally time constrained occurrences (e.g., powerlifting) to repeated, high force, short time instances (e.g., sprinting). Regardless of the context, the creation and utilization of force underpins all human movement. Strength is defined as the requisite development of this force, occupying varying velocities of movement and a complex interaction of neuromuscular variables (Stone, 1993). Harnessing maximal strength can lead to improvements in measures of sport performance (e.g., peak power and peak rate of force development, running economy, change of direction) (McGuigan et al., 2012; Stone et al., 2002; Balsalobre-Fernández et al., 2016; Spiteri et al., 2014).

Currently, researchers have attempted to understand the force production capabilities and differences in other various performance markers of numerous collegiate sports, such as throwing, women's lacrosse, American football, men's soccer, and others (Stone et al., 2003; Hoffman et al., 2009; Daniel, 1999; Ishida et al., 2021). Variability in the methods used (i.e., one repetition maximum vs. isometric force plate testing) and the athletes tested (e.g., division III) creates an incomplete picture of the strength and power characteristics of top athletes within the National Collegiate Athletics Association (NCAA) regarding team and individual sports. The purpose of this study is to better understand existing differences in isometric strength characteristics with static and countermovement jumps amongst various NCAA division I teams.

Methodology

Subjects: Eighty-two females (mean ± *SD*: weight, 67.96 kg ± 9.62 kg) and Ninety-two males (weight, 83.81 kg ± 13.77 kg) within the NCAA Division I participated in this study. Female athletes included in the study were from a variety of sports, including track & field (n = 16), rowing (n = 28), gymnastics (n = 16), and swimming (n = 22). Male athletes included were from baseball (n = 37), swimming & diving (n = 26), and wrestling (n = 29). This study was granted approval by West Virginia University's Institutional Review Board.

Design: The experimental design of this study was hypothesis-generating.

Methodology: Technology in the study included force-plates to measure static jump height (SJ) and countermovement jump (CMJ) height – both loaded (20 kg) and unloaded (0 kg). Additional force plates were used to test the isometric mid-thigh pull (IMTP). All tests created a comprehensive measure of the athlete's force–related performance characteristics.

Isometric mid-thigh pull test.

Statistical Analysis: A Pearson's Correlation Coefficient was conducted to assess the relationship between selected force-time variables and CMJ and SJ height (0 kg and 20 kg). Criteria used to determine the strength of the relationship was: trivial (r < .001), small (r =.1 to .2), moderate (r =.3 to .4), strong (r =.5 to .6), very strong (r =.7 to .8), nearly perfect (r =.9 to 1.). An alpha level of P ≤ .05 was used to detect significance.

Gender	Group	Sample Size (n)
Male	Strongest 5%	5
Male	Weakest 5%	5
Female	Strongest 5%	4
Female	Weakest 5%	4

Group	Variable	Mean ± SD (N/Kg^0.67)
Strong Males	IPF	259 ± 11.9
Weak Males	IPF	156.9 ± 1.1
Strong Females	IPF	209.9 ± 7.5
Weak Females	IPF	103.8 ± 8.5

Results

Variable	Male	Female
IPF Correlations		
0kg CMJ	r = 0.22	Not significant (p > .05)
20kg CMJ	r = 0.32	Not significant (p > .05)
0kg SJ	r = 0.33	Not significant (p > .05)
20kg SJ	r = 0.44	Not significant (p > .05)
RFD Correlations		
0kg CMJ	r = 0.32	r = 0.24
20kg CMJ	r = 0.39	r = 0.29
0kg SJ	r = 0.40	Not significant (p > .05)
20kg SJ	r = 0.46	r = 0.32
Allometric RFD		
0kg CMJ	(p > .05)	r = 0.31
20kg CMJ	(p > .05)	r = 0.31
0kg SJ	(p > .05)	r = 0.30
20kg SJ	(p > .05)	r = 0.35
Independent t-test		
0kg CMJ	Significant (p<.05)	Significant (p<.05)
20kg CMJ	Not significant (p > .05)	Significant (p<.05)
0kg SJ	Not significant (p > .05)	Significant (p<.05)
20kg SJ	Not significant (p > .05)	Significant (p<.05)

Discussion

As it stands, current findings support an unclear relationship between CMJ and SJ tests (20 kg and 0 kg) and isometric strength characteristics (IPF and RFD), with only male athletes displaying an enhanced relationship between peak force and force-time characteristics on both jumping tasks (weighted and unweighted). On the other hand, the findings are significant for females when the RFD values are allometrically scaled – mitigating the differences in strength abilities between athletes.

Practical Application

With an established relationship between strength ability (IPF and RFD) and force-time characteristics, coaches should consider a well-rounded periodized program, focused on enhancing strength qualities (e.g., maximal strength). With improved force production abilities, sport performance could be positively altered, creating improvements in jump height, sprint ability, running economy, and change of direction.

References

Kraemer, W. J., Ratamess, N. A., Flanagan, S. D., Shurley, J. P., Todd, J. S., & Todd, T. C. (2017). Understanding the science of resistance training: An evolutionary perspective. *Sports medicine*, *47*, 2415-2435.

Stone, M. H. (1993). Position statement: Explosive exercise and training. *Strength & Conditioning Journal*, *15*(3), 7-15.

McGuigan, M. R., Wright, G. A., & Fleck, S. J. (2012). Strength training for athletes: does it really help sports performance?. *International journal of sports physiology and performance*, *7*(1), 2-5.

Stone, M. H., Moir, G., Glaister, M., & Sanders, R. (2002). How much strength is necessary?. *Physical Therapy in Sport*, *3*(2), 88-96.

Balsalobre-Fernández, C., Santos-Concejero, J., & Grivas, G. V. (2016). Effects of strength training on running economy in highly trained runners: a systematic review with meta-analysis of controlled trials. *The Journal of Strength & Conditioning Research*, *30*(8), 2361-2368.

Spiteri, T., Nimphius, S., Hart, N. H., Specos, C., Sheppard, J. M., & Newton, R. U. (2014). Contribution of strength characteristics to change of direction and agility performance in female basketball athletes. *The Journal of Strength & Conditioning Research*, *28*(9), 2415-2423.

Stone, M. H., Sanborn, K. I. M., O'bryant, H. S., Hartman, M., Stone, M. E., Proulx, C., ... & Hruby, J. (2003). Maximum strength-power-performance relationships in collegiate throwers. *The Journal of Strength & Conditioning Research*, *17*(4), 739-745.

Hoffman, J. R., Ratamess, N. A., Neese, K. L., Ross, R. E., Kang, J., Magrelli, J. F., & Faigenbaum, A. D. (2009). Physical performance characteristics in National Collegiate Athletic Association Division III champion female lacrosse athletes. *The Journal of Strength & Conditioning Research*, *23*(5), 1524-1529.

Schmidt, W. D. (1999). Strength and physiological characteristics of NCAA Division III American football players. *The Journal of Strength & Conditioning Research*, *13*(3), 210-213.

Ishida, A., Travis, S. K., & Stone, M. H. (2021). Associations of body composition, maximum strength, power characteristics with sprinting, jumping, and intermittent endurance performance in male intercollegiate soccer players. *Journal of Functional Morphology and Kinesiology*, *6*(1), 7.