

## **Example:**

### RELATIONSHIP BETWEEN ISOMETRIC FORCE CHARACTERISTICS AND THE DIFFERENCE IN UN-WEIGHTED AND WEIGHTED VERTICAL JUMP HEIGHT

Jenna M. Kraska, Michael W. Ramsey, G. Gregory Haff, Nate Fethke, Ann M. Kinser, William A. Sands, Keith Painter, Margaret E. Stone and Michael H. Stone

Sports Performance Enhancement Consortium  
East Tennessee State University  
Johnson City, TN, USA, 37614

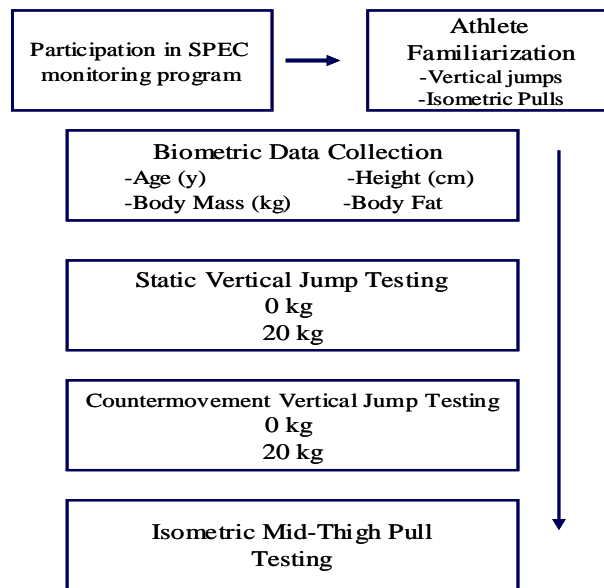
**Introduction:** Weighted and unweighted jumps may provide insights into both mechanistic and practical aspects of explosive performance. So, for strength and conditioning professionals, the monitoring of vertical jump height and jump height responses under various loading conditions is easy to perform and may be a practical assessment tool that is specific to the characteristics observed in sport. Therefore, the purpose of the current investigation was to examine the relationships between isometric force time-curve characteristics and markers of unloaded and loaded vertical jump performance. A primary purpose was to examine the relationships of maximal strength to these characteristics.

**Methods:** Forty-one female and twenty-two male USA Collegiate Division I athletes ( $n = 63$ ) active in track and field, tennis, softball, soccer, and volleyball participated in the study. Athletes read and signed written informed consent documents pertaining to the long-term athlete monitoring program and all testing procedures in accordance with the guidelines of East Tennessee State University's Institutional Review Board.

Athlete height was measured using a stadiometer and recorded to the nearest 0.1 cm. Body mass was determined using an electronic scale and body composition was determined with, air displacement plethysmography (BodPod, Life Measurement Incorporated, Concord, CA). Vertical jump height was derived from flight time using a force plate. Maximum strength characteristics were measured by an isometric mid-thigh pull. Isometric peak force (IPF), force at 50, 90 250 ms and rate of force development (IRFD) were measured by force-time curve analyses using customized signal processing software (LabView, National Instruments, Austin, TX). Reliabilities for these measures were excellent ( $ICC\alpha \geq 0.88 - 0.99$ )

Relationships between variables were assessed using a Pearson correlation procedure. Additionally a subgroup ( $n = 6$ ) of the strongest five percent of males and females (3 males + 3 females) were compared to a subgroup ( $n = 6$ ) of the weakest five percent males and females (3 males + 3 females). Athletes were placed into weak or strong groups according to their allometrically scaled isometric peak force values (IPFa). Independent samples t-Tests were used to assess differences between means (strong group IPFa =  $232.4 \pm 28.4 \text{ N/kg}^{0.67}$ , weak IPFa =  $123.18 \pm 18.87 \text{ N/kg}^{0.67}$ , ( $p \leq 0.05$ ). Due to the large number of pair-wise comparisons between groups, the Holm's Sequential Bonferroni method was used to control for type I errors. Cohen's effect sizes ( $d$ ) were also calculated. The experimental design is shown in Figure 1:

**Fig. 1 Basic Experimental Design**



**Results:** Athletes ( $n = 63$ ) were  $19.9 \pm 1.3$  yrs.;  $172.8 \pm 7.7$  cm in height and their body mass was  $72.9 \pm 19.6$  kg. There was a very strong correlation between IPF and IRFD ( $r = 0.88$ ,  $p \leq 0.05$ ) agreeing with previous literature (1, 2). IPF showed moderate to strong correlations with F50 ( $r = 0.85$ ), F90 ( $r = 0.42$ ) and F250 ( $r = 0.93$ ). Correlations of IPF and percent decrements in jump height ranged from moderate to strong negative correlations indicating stronger athletes lost less height. Compared to weak athletes, strong athletes had greater values for all force measures and for IRFD ( $p \leq 0.5$ ). Differences between strong and weak groups showed that stronger athletes jumped higher (SJ 0kg =  $30.8 \pm 9.7$  vs  $23.7 \pm 4.9$  cm,  $p \leq 0.5$ ,  $d = 0.92$ ; CMJ 0 kg =  $33.5 \pm 10.8$  vs  $28.3 \pm 6.3$   $p \leq 0.05$ ,  $d = 0.60$ ; SJ 20 kg =  $25.4 \pm 8.3$  vs  $16.7 \pm 4.8$  cm,  $p \leq 0.05$ ,  $d = 1.28$ ; CMJ 20kg =  $27.6 \pm 8.6$  vs  $18.7 \pm 5.3$ ,  $p \leq 0.05$ ,  $d = 1.24$ ). The strong group had smaller decrements (SJ =  $17.8 \pm 3.4$  vs  $30.4 \pm 7.8$  %,  $p \leq 0.5$ ,  $d = 2.10$ ; CMJ =  $17.4 \pm 4.8$  vs  $34.5 \pm 7.8$  %,  $p \leq 0.05$ ,  $d = 2.65$ ).

**Discussion:** Three important findings were associated with the current investigation: First, strong relationships were observed between maximum strength (IPF), IRFD and F50, F90, F250. It is unclear exactly why increased maximum strength is associated with increased RFD, but it may be related to alterations in the H-reflex. Second was the association of maximum strength characteristics (e.g. IPF, IRFD) with jump capabilities. Additionally, assuming that the isometric measures are indicative of striking, sprinting and jumping (i.e. force at 50, 90, and 250 ms) then stronger athletes measured in this manner can produce superior results in these activities. The third important finding was the observation that stronger athletes have smaller decrements in vertical jump heights associated with weighted jumps compared to weaker athletes. There are several potential underlying reasons for these observations. Training studies have shown increases in neural drive (IRFD) associated adaptations in contractile strength of skeletal muscle (2). Furthermore, athletes that are found to be more explosive, which may be strongly related to their nervous system capabilities, are often found to possess high levels of strength.

Thus maximum strength appears to be an important underlying mechanism that influences both un-weighted and weighted jumping and by extrapolation, explosive exercises.

**References:**

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