# EVALUATING STRENGTH QUALITIES OF ATHLETES USING RELATIONSHIPS BETWEEN JUMP PROTOCOLS

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Understanding the relationships between jump assessments may provide information of an athlete's strength qualities. Elastic Utilisation Ratio (EUR) is calculated between countermovement jump (CMJ) and squat jump (SQJ) height, and is suggested to describe the stretch-shortening cycle ability of an athlete. Yet, knowledge of what constitutes a typical EUR range for an athlete remains unclear. The purpose of this study was to assess jump performance and the EUR of athletes from two sports (soccer and distance runners) using a portable forceplate. SQJ and CMJ heights were highly correlated (r>.90). Linear regression and standard error of estimate statistics were then used to estimate CMJ height and derive an expected EUR range. It was concluded, those athletes outside this predicted EUR range would benefit from specific training.

**KEYWORDS:** jump assessments, athletes, strength qualities, kinetics.

## INTRODUCTION:

A battery of jump assessments on a forceplate can be a useful monitoring tool to enable the coach to better understand the strength qualities of their athletes and to aid the design specific resistance training objectives (Bradshaw & Le Rossignol, 2004). The Quattro Jump System (Kistler, Switzerland) is a portable forceplate which has accompanying software to evaluate a number of jump assessments for such monitoring purposes. Almost all sporting movements require the utilisation of the *stretch shortening cycle* (SSC), therefore jump assessments should be selected based on the ability to evaluate such movements. A sequence of multiple in-place jumps can provide information of the athlete's ability to utilise elastic energy in the lower leg when straight leg jumps are performed (CJS), or the whole leg when the bent leg assessment is employed (CJB) on a single forceplate system (Bosco, 1992). The most common assessment, however, is the countermovement jump (CMJ) which is highly dependent upon impulse and involves a slower SSC movement (Winter & MacLaren, 2001). Unlike the faster SSC movements such as the multiple in-place jumps described, the CMJ relies heavily on the active force developed during the propulsive phase and less on stored elastic energy (Komi, 2003).

In athletes, height from CMJ has been associated with muscular strength, sprint performance and other desirable qualities (Wislöff et al., 2004). The squat jump (SQJ), similar to the CMJ has been associated with muscular strength, however, the SQJ involves the concentric phase movement of the jump only (i.e. the upward movement) and therefore the time to actively develop muscular force is less than the CMJ, making it more dependent upon the rate of force of development and peak power. Differences between squat and countermovement jumps have been well documented (e.g. Bobbert et al., 1996). From this research, expected differences between SQJ and CMJ performance are approximately around 10%. Recently, the use of the ratio between CMJ and SQJ (CMJ/SQJ) has been suggested as a useful variable to monitor athletes during the season and to assist in training prescription (McGuigan et al., 2006). Termed the 'Elastic Utilization Ratio' (EUR) this variable can be calculated using either jump height (EUR jump) or peak power (EUR power) results and have been suggested to essentially assess the same strength quality (McGuigan et al.). Data for EUR jump and EUR power values have been reported for a number of individual sports, differences between genders, and across training phases (e.g. Stone et al., 2003; McGuigan et al., 2006). Following assessment, an athlete with a high EUR (i.e. a large difference between CMJ and SQJ) is considered to utilise force developed during the CMJ, but has less ability to actively develop force when constrained to the concentric phase only. For such an athlete prescription of specific resistance training would include exercises to develop speed-strength (i.e. explosive movement plyometrics and jerks). In contrast, for the athlete with a low EUR it has been suggested that resistance training would be better directed at developing muscular strength (Siff, 2003).

At present, although changes over time have been well documented (Stone et al., 2003; McGuigan et al., 2006) clarity of how EUR can be used to determine exercise prescription remains a judgement call for the strength coach. Specifically, for the coach deciding what constitutes a high or low EUR, requiring specific exercise prescription is not well understood. Furthermore, the relationship between SSC jump assessments and the EURs have not been described. Therefore the objectives of this study included investigating; EURs calculated using jump height and peak power; determine suitable cut-off values for EURs to help in exercise prescription; the relationship between jump assessments and EURs to help explain what is being assessed.

## METHOD:

The participants in this study were all male state institute scholarship athletes involved in competitive distance running and soccer (n = 13; age = 18.2 ± 3.3 years, stature = 178.1 ± 6.2 cm; mass = 70.1 ± 5.3 kg). All were injury free at the time of testing. The criteria for injury was when an athlete had not participated in training for more than 7 days and/or had not participated in two sequential competitions at the time of testing (Noyes et al, 1988).

The multiple jump assessment included five countermovement jumps (CMJ), five squat jumps (SQJ), a double legged series of ten straight-legged jumps (CJS) where the hip and knees were systematically braced in an extended position, and a double legged series of ten bent-legged jumps (CJB). During all jumping tasks, participants maintained an upright position with their hands held loosely on the hips throughout. All jumping data were collected using a portable forceplate (Quattro, Kistler, Switzerland, 500 Hz). All force data were collected from the battery of jump assessments (CMJ, SQJ, CJS and CJB) were analysed using Quattro Jump software (Kistler, Switzerland) and power was normalised to W/kg. EUR jump and EUR power was calculated as described by McGuigan et al. (2006). All statistical tests were run in SPSS version 14.0. All pooled (i.e. soccer and runner groups combined) data were deemed normal following critical appraisal (Peat & Barton, 2005). Bivariate correlation (Pearson's) was used to explore relationships between two variables, when an acceptable correlation ($r > .080$) was found, linear regression models were constructed. To test for a difference between variables a paired t-test was used. Statistical significance was set at an alpha level of 0.05.

## RESULTS AND DISCUSSION:

The descriptive statistics for the CMJ, SQJ, EUR jump and EUR power are presented in the Table 1. A 5% difference ($p = 0.001$) between CMJ and SQJ height was found for the pooled data, which was lower than 10% difference previously reported (e.g. Bobbert et al., 1996). Peak power, however, failed to show a difference between groups (mean difference = 1%; $p = 0.508$). The minimal differences observed between CMJ and SQJ peak power results for the pooled data supports previous published concerns regarding its use when derived from CMJ (Winter & MacLaren, 2001).

**Table 1 The individual group and combined descriptive statistics for countermovement (CMJ), squat jump (SQJ) measures (height and peak power) and Elastic Utilization Ratio (EUR) derived from jump height and peak power.**

| Group | CMJ | | SQJ | | EUR | |
|---|---|---|---|---|---|---|
| | Ht(cm) | $Power_{Peak.}$ (W/kg) | Height (cm) | $Power_{Peak}$ (W/kg) | Height Method | Power Method |
| Soccer | 45.26 ± 4.6 | 46.7 ± 3.8 | 43.2 ± 3.8 | 45.7 ± 4.5 | 1.05 ± 0.04 | 1.03 ± 0.09 |
| Runners | 47.1 ± 9.9 | 50.9 ± 16.2 | 45.2 ± 9.03 | 50.8 ± 17.1 | 1.04 ± 0.03 | 1.01 ± 0.06 |
| Pooled | 46.1± 7.3 | 48.7 ± 11.0 | 44.1± 6.5 | 48.0 ± 11.8 | 1.04 ± 0.04 | 1.02 ± 0.07 |

For the pooled data, no difference ($p = 0.284$) was found between the EUR jump height and EUR jump power measures. As previously reported (McGuigan et al., 2006) the EUR ratio derived from peak power (1.02± 0.07 W/kg) was lower than the corresponding EUR ratio derived from jump height (1.04± 0.04 cm). Interestingly, EUR jump height and EUR jump power were poorly correlated (r = -0.20), suggesting that these errors in measures for EUR are caused by artefacts (McGuigen et al., 2006). This may be due to the lack of stability of peak power during the assessment of CMJ (Winter & MacLaren, 2001). When the individual sports were analysed, similar trends from the pooled data were found. No differences between groups were found for EUR jump height (p = 0.745), EUR jump power (p = 0.647), CMJ height (p = 0.666), SQJ height (p = 0.600), CMJ peak power (p = 0.515), and SQJ peak power (p = 0.460). These findings support the use of pooled data from different athletic groups to improve the statistical power of the analysis (Peat & Barton, 2005).

SQJ height was strongly related (r = 0.979) with CMJ height for pooled data, in addition similar high correlations were revealed in the soccer players (r = 0.917) and runners (r = 0.994). These relationships are illustrated in Figure 1. Linear regression was performed using CMJ height as the dependant variable and SQJ height as the independent variable. The resultant equations (*y = mx+c)* were *CMJheight = 1.094 (SQJheight) -2.141* (standard error of estimate (SEE) = ±1.6 cm) for pooled data; *CMJheight = 1.115 (SQJheight) -2.907* (SEE = ± 2.0 cm) for the soccer group and *CMJheight = 1.095 (SQJheight) -2.367* (SEE = ± 1.2 cm) for the runners. From the regression analysis CMJ height was predicted from a known SQJ height. Furthermore, the SEE provides upper (+) and lower (-) cut-off values for expected CMJ height in the units of measurement with 68% confidence. The upper and lower cut-off values for predicted CMJ height were then used to determine EUR jump cut-off values (see examples for observed 45 cm SQJ height Table 2). With knowledge of the expected cut-off values for EUR jump height for a given SQJ height, a comparison of the individual's observed (measured) EUR jump height and the predicted EUR jump height range can be used to assess the athlete. When the score exceed the predicted cut-off values, an informed decision can be made about the athlete's training goals. That is, if the observed EUR jump height is greater than the upper predicted value, a speed-strength training prescription would be recommended (Siff, 2003).

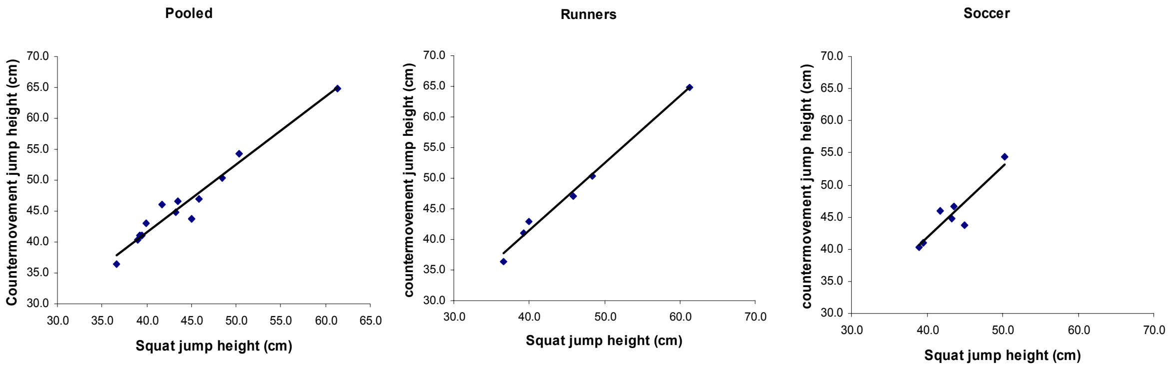


Figure 1 The positive, linear relationship observed between squat jump height and countermovement jump height for the pooled data, and for the individual sports (soccer and running).

The study also involved additional jump protocols used in the testing battery to assess the faster component of SSC for the whole (CJB) and lower leg only (CJS). Descriptive statistics are reported in Table 3 for pooled and individual group data. Differences between soccer and runners were not significant for CJB height (p = 0.147), CJB average power (p = 0.222); CJS height (p = 0.741) and CJS average power (p = 0.939). When correlation analysis was performed EUR jump height was not related to any of the jump assessments (r ranged from -0.092 for CJS height to 0.147 for CMB power). The poor correlation shown between EUR jump and the SSC assessments may suggests that performance of faster SSC activities are not related to the strength qualities assessed by EUR jump. EUR jump may measure effectively the ability of the athlete to explosively initiate movement from a stationary start compared to their ability to produce impulse under more favourable conditions (i.e. CMJ). This strength quality is required in sporting activities and has previous been described as starting-strength (Siff, 2003)

**Table 2 The predicted countermovement jump (CMJ) height, predicted Elastic Utilization Ratio using the jump height method (EUR jump height) with expected upper and lower cut-off values derived from known squat jump (SQJ) height for pooled, soccer and runner group (m and c refer to the constants for the regression equation)**

| Group | M | SQJ observed (cm) | c | CMJ predicted (cm) | upper | lower | EUR | upper | Lower |
|---|---|---|---|---|---|---|---|---|---|
| Pooled | 1.094 | 45.0 | -2.141 | 47.1 | 48.7 | 45.5 | 1.05 | 1.08 | 1.01 |
| Soccer | 1.115 | 45.0 | -2.907 | 47.3 | 49.3 | 45.3 | 1.05 | 1.09 | 1.01 |
| Runners | 1.095 | 45.0 | -2.367 | 46.9 | 48.1 | 45.7 | 1.04 | 1.07 | 1.02 |

**Table 3 The descriptive statistics for the Stretch Shortening Cycle (SSC) assessments using Continuous Jumps with Bent (CJB) and Straight (CJS) legs for pooled, soccer and runner groups.**

| | CJB Height (cm) | CJB Ave. power (W/kg) | CJS Height (cm) | CJS Ave. power (W/kg) |
|---|---|---|---|---|
| Soccer | 30.7 ± 5.6 | 30.4 ± 5.4 | 28.8 ± 3.4 | 32.2 ± 6.2 |
| Runners | 36.9 ± 8.1 | 26.3 ± 6.1 | 29.8 ± 6.3 | 32.5 ± 9.0 |
| Pooled | 33.4 ± 7.2 | 28.5 ± 5.9 | 29.3 ± 4.7 | 32.4 ± 7.3 |

## CONCLUSION:

The findings of this study are limited to the sample of athletic groups tested and require further investigation with a larger sample size. However, the use of EUR jump height and EUR jump power inter-changeably appears to present difficulties which may be caused by peak power. In addition, when such high correlations are found between SQJ and CMJ, the use of linear regression to help evaluate EUR jump scores, design and monitor training appears feasible.

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