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Research Note

Eccentric Utilization Ratio: Effect of Sport and Phase of Training

Michael R. McGuigan,[1] Timothy L.A. Doyle,[1,2] Michael Newton,[1] Dylan J. Edwards,[1] Sophia Nimphius,[1] and Robert U. Newton[1]

[1]*School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Joondalup, Western Australia, Australia;* [2]*School of Health and Physical Education, University of Notre Dame Australia, Fremantle, Western Australia, Australia.*

Abstract. McGuigan, M.R., T.L.A. Doyle, M. Newton, D.J. Edwards, S. Nimphius, and R.U. Newton. Eccentric utilization ratio: Effect of sport and phase of training. *J. Strength Cond. Res. 20(4):992–995. 2006.*—The eccentric utilization ratio (EUR), which is the ratio of countermovement jump (CMJ) to static jump (SJ) performance, has been suggested as a useful indicator of power performance in athletes. The purpose of the study was to compare the EUR of athletes from a variety of different sports and during different phases of training. A total of 142 athletes from rugby union, Australian Rules Football, soccer, softball, and field hockey were tested. Subjects performed both CMJ and SJ on a force plate integrated with a position transducer. The EUR was measured as the ratio of CMJ to SJ for jump height and peak power. The rugby union, Australian Rules Football, and hockey athletes were tested during off-season and preseason to provide EUR data during different phases of training. For men, EUR for soccer, Australian Rules Football, and rugby was greater than softball (effect size range, 0.83–0.92). For women, EUR for soccer was greater than field hockey and softball (0.86–1.0). There was a significant difference between the jump height and peak power method for the Australian Rules Football, rugby, and field hockey tests conducted preseason ($p < 0.05$). For field hockey, there was a significant increase in EUR from off-season to preseason. Athletes in sports such as soccer, rugby union, and Australian Rules Football appear to have higher EUR values, which reflects the greater reliance on stretch shortening activities in these sports. It does appear that EUR can be used to track changes in training with the values significantly increasing from off-season to preseason. The EUR provides the practitioner with information about the performance of athletes and appears to be sensitive to changes in the type of training being undertaken.

Key Words. countermovement jump, squat jump, stretch-shortening cycle, power

Introduction

Strength and conditioning professionals are interested in reliable and valid tests of muscular performance. Vertical jump testing is a common method used by coaches to assess muscular power and jump height. The squat jump (SJ) and the countermovement jump (CMJ) are 2 common tests that are used to discriminate the effect of the stretch-shortening cycle (SSC) in various athletic populations. Recent work has shown that these tests are reliable and valid tests for the estimation of explosive muscular power (13). Research studies have also demonstrated that peak power values derived from vertical jump tests can be a valuable tool for assessing weightlifting performance (6).

The ability to utilize the SSC efficiently is a critical factor in many sports. A number of different approaches have been used by sports scientists to examine the effect of SSC and its relationship to athletic performance (4). Performance of the SSC is commonly measured using an added prestretch to a movement, such as comparing CMJ performance with SJ performance (11). Researchers have measured SSC performance from jump heights of CMJ and SJ as an augmentation of a prior stretch (18). Prestretch augmentation can be calculated as a percentage with % prestretch augmentation = $[(\text{CMJ} - \text{SJ}) \times \text{SJ}^{-1}] \times 100$. Another approach is to measure reactive strength (calculated as CMJ − SJ height) (19). This is considered to be a measure of the ability to utilize the muscle prestretching during the CMJ (7, 19).

There are some limited data from soccer that reports on "rocket jumps," which are the equivalent of SJ (concentric only jumps for maximum height), that relates performance in a rocket jump to performance in a typical CMJ (1). However, this research is limited and has not been widely used by strength and conditioning professionals and used in practice. Although this literature has recommended that the ratio of the performance on the CMJ compared to the SJ should exceed 1 in well-trained athletes, this suggestion needs support from across a number of sports. Therefore, the primary purpose of this investigation was to compare the eccentric utilization ratio (EUR) in a variety of different sports and to measure the EUR at different phases of the training year to investigate whether the EUR may be sensitive to changes in training programs. A secondary purpose was to compare the use of jump height and peak power in the calculation of EUR.

Methods

Experimental Approach to the Problem

To answer the research questions, there were 2 parts to the analysis. A cross-sectional comparison of athletes was completed across a range of different sports including soccer, Australian Rules Football, rugby union, and softball. This enabled us to investigate the EUR characteristics of different sports to investigate if there were any differences between sports. All testing took place either during periods that would be classified as out of season, or the off-season, and immediately prior to the commencement of the competitive season. A secondary purpose was to compare the use of jump height and peak power in the calculation of EUR. Finally, measures of EUR were obtained during the off-season and immediately prior to the start of the competitive season for 3 sports (rugby union, Australian Rules Football, and field hockey) to investi-

TABLE 1. Eccentric utilization ratio (EUR) for the different sports.

Sport	Gender	N	EUR (jump height)	EUR (peak power)
Soccer	Men	28	1.14 ± 0.15	1.03 ± 0.20
	Women	12	1.17 ± 0.16	1.11 ± 0.20
Softball	Men	16	1.03 ± 0.09	1.00 ± 0.17
	Women	25	1.04 ± 0.13	1.02 ± 0.13
Australian Rules Football	Men	26	1.10 ± 0.08	1.03 ± 0.20
Rugby union	Men	11	1.13 ± 0.14	1.01 ± 0.20
Field hockey	Women	24	1.02 ± 0.13	1.05 ± 0.18

TABLE 2. Eccentric utilization ratio (EUR) for the off-season and preseason training periods.

Sport	Training period	EUR (jump height)	EUR (peak power)
Australian Rules	Off-season	1.10 ± 0.08	1.03 ± 0.20
Football	Preseason	1.14 ± 0.10	1.03 ± 0.07*
Rugby union	Off-season	1.13 ± 0.14	1.01 ± 0.20
	Preseason	1.33 ± 0.23†	1.19 ± 0.09*
Field hockey	Off-season	1.02 ± 0.13	1.05 ± 0.18
	Preseason	1.08 ± 0.10	1.26 ± 0.21*†

* Significant difference between jump height and peak power method.

† Significant difference between off-season and preseason.

gate whether the EUR is sensitive to the stage of the annual periodized plan. Such data would be of particular interest to the strength and conditioning professional as it would provide a simple measure that could be used to monitor training status of athletes.

Subjects

A total of 142 athletes (81 men, 61 women) were tested from the sports of rugby union, Australian Rules Football, soccer, softball, and field hockey in this investigation (Table 1). The rugby union, field hockey, and Australian Rules Football athletes were also tested during the off-season and preseason (immediately prior to the start of the season).

Testing Protocols

The subjects performed unweighted CMJ and SJ without the aid of an arm swing; this was standardized by having participants hold a lightweight bar (plastic pipe less than 1.0 kg) on their shoulders. The SJ involved the subject flexing the knee to approximately 90°, maintaining the position for 3 seconds, and then jumping on the command "go." The CMJ was performed under the same conditions but involved flexion of the knee followed immediately by extension of the legs.

Jump height was recorded using a linear position transducer (model PT9510; Celesco, Canoga Park, CA) interfaced with a personal computer running Ballistic Measurement System software (Fitness Technologies, Adelaide, South Australia). Test-retest reliability for jump height and peak power in our laboratory demonstrated intraclass correlation coefficient of $R \geq 0.96$ and coefficient of variation <3%.

Statistical Analyses

One-way analysis of variance was used to assess differences between sports and EUR methods. An α level of $p \leq 0.05$ was used to define significance in this investigation. The magnitude of the differences between values were also interpreted using the effect size (ES) for each outcome measure according to Thomas and Nelson (17). ES = (M2 − M1)/s where M2 = within-group average of 1 group, M1 = within-group average of 1 group, and s = pooled standard deviation for all subjects combined. As per Thomas and Nelson (17), large, moderate, and small ES values were defined as ≥0.80, ≥0.50, and ≥0.20, respectively.

RESULTS

The results for the EUR of the different sports are provided in Table 1, whereas Table 2 shows the results for off-season and preseason. There was a significant difference between the jump height and peak power method for the Australian Rules Football, rugby, and field hockey tests conducted during preseason testing ($p < 0.05$). For the field hockey and rugby athletes, there was a significant increase in EUR from off-season to preseason ($p < 0.05$).

ES calculations showed large differences between some sports when using the jump height method. For men, EUR for soccer, Australian Rules Football, and rugby was greater than for softball (0.83–0.92). For women, EUR for soccer was greater than for field hockey and softball (0.86–1.0).

DISCUSSION

In this study, 2 tests that are commonly used to measure jumping ability were used. It is well established that subjects achieve greater jump heights and power outputs in the CMJ compared to the SJ (3). The SJ is commonly used to test the concentric strength of the leg extensors (19), whereas the CMJ is used to measure the reactive strength of the lower body (19). Jump performance has also been shown to be related to performance such as sprinting speed (15, 20). Some researchers also suggest that the CMJ is a measure of slow SSC ability due to the long duration of the lengthening-shortening contraction (19). The EUR has been proposed as an indicator of SSC performance in various sports and during different phases of training. The results of this investigation suggest that there are differences for some sports in the EUR depending on whether the jump height or peak power method is used. Athletes in sports such as soccer, rugby union, and Australian Rules Football appear to have higher EUR values (as indicated by the large ES), which possibly reflects the greater reliance on stretch shortening activities in these sports. We did not observe any specific gender differences in EUR. One study by Carlock et al. (6) found that the average jump height difference between the CMJ and SJ in weightlifters was 5.4% for women and 11.8% for men. This could, however, be a result of the different training levels of the subjects who were tested. Training status does appear to be an important consideration in power production (16).

There are limited studies that have investigated the relationship of CMJ and SJ in different athletic populations. Other authors have shown no difference in EUR (which they termed the SSC Performance Index) between sprinters and endurance athletes (9), even though the sprinters performed better than the endurance athletes during SSC movements. A study by Kubo et al. (12) demonstrated that the CMJ/SJ ratio of long distance runners was significantly lower than untrained subjects. This could potentially be due to the effect of endurance training of the size of fast twitch fibers and hence strength and power. A recent study tracked muscular power changes in collegiate women gymnasts over a 3-year period (8). Although the EUR was not specifically measured, it did appear that compared to the CMJ data, the SJ peak power output was significantly lower than the CMJ for the last 18 months of the tracking period. In the present investigation, there did appear to be some differences in EUR depending on the phase of training. There was a significant difference between off-season and preseason for the field hockey players, with higher values recorded immediately preseason (1.26 vs. 1.05). This could reflect the increased amount of power training and SSC activities that are usually incorporated into the preseason training of athletes.

Several interpretations have been offered to explain the performance difference between the CMJ and SJ. Previous research has reported that the performance difference between these jump types might result from a difference in work performed by the hip extensors rather than from the effects of stored elastic energy (2). According to simulation results performed by Bobbert et al. (2), the explanation for the enhancement of performance in CMJ over that in SJ seemed to be that the countermovement allowed the muscles to build up a precontraction active state in which there is a high fraction of attached cross-bridges and force before the onset of shortening. Therefore the active muscles are able to produce more work over the initial part of their shortening distance. It can, therefore, be argued that while CMJ produces higher jumping than SJ due to several mechanical mechanisms, the CMJ is not a suitable model of an efficient SSC. It has also been suggested that the level of muscle activation, rather than the storage and reutilization of elastic energy, is critical for potentiation of performance in SSC movements (3). Therefore, we have chosen to use the term eccentric utilization ratio (EUR).

SJ is commonly compared to CMJ to examine the influences of the countermovement in producing greater jump heights, in addition to the neuromuscular system to rapidly develop force (10). Bobbert and Casius (2) recently proposed that a large difference between CMJ and SJ could be expected in subjects that develop force slowly. Therefore, it may be prudent for these subjects to focus on activities that promote rate of force development. They also suggest that a small difference is expected in subjects who build up force quickly. These authors also raise the possibility that the resolution of experimental studies may be too low to detect subtle differences in the difference between CMJ and SJ.

It is important to remember that the EUR performance indices merely describe the relationship between CMJ performances to SJ. An artifact of this calculation procedure is that relative changes in SJ performance can misleadingly elevate the SSC performance indices. It is also possible that surface types across the different sports could impact the findings. For example, surfaces on which hockey players compete and train would differ from those of the other sports and the resulting impacts would vary. However, we did not specifically measure these differences. It is also likely that the different training regimens of the athletes would impact the findings, but we do not have detailed information on the type of training being conducted during the different training phases. Well-controlled training studies are needed to confirm the efficacy of EUR as an indicator of training status. The incorporation of SSC exercises into a training program has generally been shown to improve power production and jump performance (14). However, not all studies have shown significant improvements in peak power following SSC training programs (5).

Practical Applications

Monitoring changes in performance of athletes over time is an important process for strength and conditioning professionals and sports scientists. The EUR provides the strength and conditioning practitioner with information about of the SSC performance of athletes across a range of different sports. It also appears to be sensitive to changes in the type of training being undertaken by the athletes. Presented here is a simple manipulation of data that most teams would routinely collect that can provide some insight to SSC performance of their athletes. Results for the EUR can be derived from jump height and power output and both methods appear to give essentially the same information.

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Address correspondence to Dr. Michael R. McGuigan, m.mcguigan@ecu.edu.au.