Original Article

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Article Title:

Comparison of a countermovement jump test and submaximal run test to quantify the sensitivity for detecting practically important changes within high-performance Australian rules football.

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Abstract

Purpose: The purpose of this study was to determine the typical variation of variables from a countermovement jump (CMJ) test and a submaximal run test (SRT), along with comparing the sensitivity of each test for the detection of practically important changes within high-performance Australian rules football (ARF) players. **Methods:** 23 professional and semi-professional ARF players, performed six CMJs and three, eight-second 50-meter runs every 30 s (SRT), seven days apart. Absolute and trial-to-trial reliability was represented as a coefficient of variation (CV) ± 90% confidence intervals (CI). Test-retest reliability was examined using the magnitude of the difference (effect size (ES) ± 90% CI) from week 1 to week 2. The smallest worthwhile change (SWC) was calculated as 0.25 x SD. **Results:** Good reliability (CVs = 6.6 – 9.3%) was determined for all variables except eccentric displacement (CV = 12.8%), with no clear changes observed in any variables between week 1 and week 2. All variables from the SRT possessed a CV < SWC, indicating an ability to detect practically important changes in performance. Only peak velocity from the CMJ test possessed a CV < SWC, exhibiting a limitation of this test in detecting practically meaningful changes within this environment. **Conclusions:** The results suggest that while all variables possess acceptable reliability, a SRT might offer to be a more sensitive monitoring tool than a CMJ test within high-performance ARF, due to its greater ability for detecting practically important changes in performance.

Keywords: test-retest, activity profile, monitoring, reliability

Introduction

It is critical that when making informed decisions regarding performance, coaches and support staff have knowledge of the typical variation or repeatability of the test being applied [1, 2]. Gaining an understanding of the meaningful change in performance is reliant on knowing if the observed change is due to the normal variation or is outside the typical variation expected to occur by chance [1]. The greater the reliability the measure has, and therefore, the lower the variability, the more certain one can be that real change in performance has occurred and correct interpretations can be made [1, 2].

For the valid interpretation of reliability outcomes, a comprehensive knowledge of the typical variation or repeatability of a test needs to account for the relationship between the smallest effect that is considered practically meaningful, and the typical variation of the measurement [1]. The smallest worthwhile change (SWC) is regarded as the smallest worthwhile change in frequency outside of the expected measurement error and the minimum change in performance required to be of meaningful consequence [1, 3, 4]. Consequently, it provides information on whether the change observed is 'real' or simply due to the error or 'noise' of the test. From a practical perspective, the error associated with a performance measure needs to be less than the SWC, as this allows valuable and accurate information on recovery status and can support decisions such as, rotations and recovery practices, within and after games and training [1, 5].

For the monitoring of neuromuscular fatigue (NMF) within high-performance team sports environments, the countermovement jump (CMJ) test is recognised as the reference standard test [6, 7]. It has been shown to possess both robust reliability and validity [1, 6, 8, 9], and is generally performed using a digital optical encoder, force plate or contact mat. Due to this technology, the result has been a large number of different kinematic and kinetic variables available for monitoring, measuring both the concentric and eccentric phase, gross values of movement output (e.g. jump height) and values representing jump strategy (e.g. eccentric displacement) [1, 9, 10]. With this enhanced ability to monitor and a large number of variables on offer, it has been recommended to measure variables representing both movement output and jump strategy as this will allow the most sensitive approach to monitoring changes in NMF status [1, 9, 10]. Specifically, the variables shown to be most useful in indicating neuromuscular status, are changes within eccentric displacement, jump height, peak velocity, mean power and/or peak force [1, 9, 11, 12]. For a variable to be considered useful in monitoring the changes in NMF status it needs to be sensitive enough to detect the impact of fatiguing interventions while also having high reliability [13]. The above mentioned variables have been shown to be the most dependable in detecting changes in post-exercise NMF in a variety of different environments [6, 9, 11, 13], while also possessing both high reliability and repeatability [1, 8, 11, 12]. However, it has also recently been shown that reductions within the individual vectors of 100 Hz triaxial accelerometers during a submaximal run test (SRT) can provide insight into an athlete's state of NMF [11]. When monitoring high-performance ARF players, Garrett el al. [11] observed that players in a state of post-match NMF had corresponding reductions in the individual vectors of triaxial accelerometers during a SRT. This recent finding is in conjunction with recent evidence that has suggested that the underlying mechanisms of fatigue may be task specific [11, 14]. Team sports such as Australian rules football (ARF), which involves high- intensity repeat sprint efforts, numerous changes of direction, along with accelerations and decelerations, all interspersed with periods of moderate to low intensity running [15], may benefit from a method of monitoring NMF via the running gate or activity profile. Therefore, the purpose of this study was to determine the typical variation of a CMJ test and SRT within a high-performance ARF environment and compare the sensitivity of each test for detecting practically important changes within high-performance ARF. Practically, this will provide sport science practitioners with insight into the most sensitive tool for monitoring post-exercise NMF in a predominantly running based team sports such as ARF.

Methods

Subjects

Participants were twelve professional ARF players (age; 22.5 ± 4.2 years, body mass; 87.4 ± 6.8 kg, height; 190.1 ± 6.5 cm, years on an Australian Rules Football (AFL) list; 2.4 ± 2.9 years) from one Australian Football League club, and eleven semi-professional ARF players (age; 22.3 ± 2.9 years, body mass; 80.9 ± 6.2 kg, height; 184.4 ± 5.8 cm) from one South Australian National Football League club. All participants performed testing as part of their normal training regime and were familiar with procedures prior to the study. To be eligible for inclusion, all subjects were required to be cleared by the club's medical staff to participate in each exercise. Informed, written consent was obtained from all participants and was approved by the University of South Australia's Human Ethics Committee.

Design

To examine the typical variation and sensitivity of variables from a CMJ test and SRT, all subjects performed six CMJs, and three submaximal 50 metre runs (SRT), seven days apart during a normal microcycle within an ARF in-season period.

Methodology

Countermovement Jump Test (CMJ)

The CMJ test was performed using previously established protocols [1] with an average of six CMJs used for analysis. CMJ performance was obtained for analysis via an optical encoder (GymAware Power Tool, Kinetic Performance Technologies, Canberra, Australia) fixed to the ground and attached via a cable to the 400 g dowel rod. For each jump the variables obtained for analysis were: CMJ height (CMJ_H), peak velocity (PV) and eccentric displacement (ED). These variables were chosen in order to prevent a scattergun approach and have been shown to have a superior capacity in detecting changes in post-exercise NMF in a variety of different environments [6, 9, 11, 13], while also possessing high reliability within high-performance team sport athletes [1, 8, 11, 12].

Submaximal Run Test (SRT)

In order to maintain consistent methodology, the following paragraph mirrors that previously presented by Garrett and colleagues [11] for implementation of a SRT. The SRT involved three x 50-meter runs, each completed in eight seconds in a 30-second cycle. At 10 seconds before starting each run, subjects were asked to be ready, with a 3-second countdown given by one experimenter preceding each run. Subjects were instructed to perform the run in strictly eight seconds with a time check at the 25-metre halfway mark to help control for speed of the run. The GPS-embedded triaxial accelerometers unit was worn in a specialized pocket in the training and match guernsey, located between the scapulae of the participant. For each run, the variables obtained for analysis were: player load 1D up ($PL1D_{up}$) (vertical vector); player load 1D side ($PL1D_{side}$) (medio-lateral vector); and player load 1D forward ($PL1D_{fwd}$) (anterio-posterior vector). PL metrics have been shown to possess high levels of validity and reliability when monitoring team sport athletes and a detailed explanation on the calculation of these metrics has been described previously [16].

Analysing the Run

In keeping with the methodology of Garrett et al. [11], GPS-embedded triaxial accelerometer data were sampled at 100 Hz resulting in ~1000 data points for each run effort. The initial 10 s of the run was used for analysis to allow full completion of the run including deceleration. To standardise the beginning of the run for each participant, the run was deemed to have begun once a velocity of 1 $m.s^{-1}$ had been reached.

Statistical Analysis

Descriptive statistics were computed for all variables from both the CMJ test and SRT and reported as mean ± SD. Following previous literature [1, 8], the absolute and trial-to-trial reliability of each variable was quantified via typical error of measurements (TEs) and expressed as a CV (± 90% confidence interval (CI)). This was calculated using the spreadsheet for reliability by Hopkins [17] with further detailed evaluation of calculations to be reviewed elsewhere (for review [1, 2]). Test-retest reliability (week-to-week) was analysed by calculating magnitude-based inferences (effect size (ES) statistic ± 90% CI) between the mean of each measure for week 1 and the mean of each measure for week 2 (i.e., difference between the mean of $PL1D_{up}$ for week 1 and the mean of $PL1D_{up}$ for week 2 etc.). As suggested by Rhea [18] for highly trained athletes, differences were classified as trivial (< 0.25), small (0.25 – 0.50), moderate (0.51 – 1.0), and large (>1.0), and declared practically important where there was a >75% likelihood of exceeding the smallest important effect size (0.25) [19]. Differences with less certainty were classified as trivial [20], with the magnitude of the difference considered 'unclear' where the 90% CI simultaneously overlapped the smallest important ES (0.25) both positively and negatively [19]. The smallest worthwhile change (SWC) was calculated as 0.25 x SD, representing a "small" effect size and the smallest beneficial change of performance [1]. Variables were considered capable of detecting the SWC if the CV ≤ SWC [1, 8].

Results

For each performance measure, mean values (± SD) and reliability estimates are listed in Table 1. Changes in the performance measures from week-to-week are presented in Figure 1, while Figure 2 illustrates the difference in the estimated typical variation as the number of trials included increased. There was no apparent change observed in any variables between week 1 and week 2. There was an approximate increase of error for most variables of 1-2% when one trial was included than when three to six trials were included. Low absolute reliability was also observed for all variables with CV's present of less than 10% (range = 6.6 – 9.3%), other than for ED (CV = 12.8%). PV from the CMJ test and all the SRT variables possessed CVs smaller than the SWC.

Insert Table 1 here

Insert Figure 1 here

Insert Figure 2 here

Discussion

In order to make an informed decision regarding athletic performance, a comprehensive understanding of the typical variation or repeatability of the test being applied is vital. The present study showed good reliability for all variables within this study. Furthermore, all SRT variables possessed a CV smaller than the SWC, and are, therefore, potentially more capable of detecting practically meaningful changes.

When monitoring an athlete's response to training and their recovery between sessions and/or weekly competitions, the focus should be placed upon short-term variability [1]. This type of reliability is most common for estimating the magnitude of error associated with test-retest designs, such as subjects tested pre- and post-intervention and includes not only the random measurement error but also the biological variation that occurs over time [1]. The results observed in this study showed no differences in performance outcome variables from week 1 to week 2 in any of the tested variables. This suggests that fatigue and learning effects did not adversely influence the results between sessions. Consequently, any changes observed when implementing within a normal training environment must be due to influences on performance, such as fatigue or super-compensation. This, therefore, supports any changes observed within regular weekly monitoring of either test can be that of a real change in performance, or of a fatigued state, and not that of random measurement error, or mainly, biological variation.

It is also essential to have an understanding of the trial-to-trial reliability due to it having limited scope for biological changes. The error estimate associated with trial-to-trial reliability can, therefore, be attributed to random measurement error alone [2]. This value allows for an accurate estimation of the true likely range of the chosen outcome variables, which can assist the practitioner in understanding the amount of error that can occur within a single measurement [1]. Our results indicate that when a single trial CMJ test was used, the practitioner can expect an approximate increase of error for most variables of 1-2%, compared to if three to six trials are used. Although it has previously been recommended that at least six jumps are required to reduce variability [1, 21], in this population of team sport athlete, it seems that at least three trials are sufficient to maintain acceptable reliability. However, with only an increase of error of 1-2%, using only a single trial may increase the feasibility of the test as a weekly monitoring tool in a sport such as ARF that has large squad numbers. Nonetheless, in order to reduce the estimated error and tighten the reliability of this procedure, from these results, it is recommended to perform at least three trials of a CMJ test. A similar increase of error of approximately 1-1.5% was also observed for the SRT when a single run was used compared to if three runs were used. Yet, due to the small decrease in estimated error as each run was included, it may be that including more run efforts may further reduce the random measurement error of the test. Nevertheless, with the current test taking less than two minutes to complete, the inclusion of more trials may not have a significant impact upon the estimated error but have an adverse effect on the practicality of the test within a high-performance environment. Therefore, it is recommended that the current protocol of the SRT is sufficient to maintain low error estimate and high practicality.

Although there is no predetermined standard for acceptable CV values, in practical settings for monitoring tools, it is generally considered that ‘good’ reliability is set at those with CVs <10% [1, 22]. However, having a set criterion for ‘good' reliability based simply off a CV alone does not provide information about the meaningfulness of the change [1]. A test can, therefore, possesses ‘good’ reliability, but where a variable has a CV greater than the SWC, it would indicate reduced practicality of that variable [1]. It is generally agreed that the SWC is the minimal practically meaningful change in performance [1, 5]. In relation to performance, the typical variation (CV) of a test needs to be smaller than the SWC to be considered practically meaningful [1, 5]. In our analysis, all SRT variables demonstrated a CV < SWC. This would indicate that the variables of the SRT are useful measures when monitoring performance in ARF players. However, although the CMJ test variables possessed ‘good’ reliability, only PV possessed a CV smaller than the SWC. While PV has the ability to detect the smallest worthwhile effect on performance, the inability of the other CMJ variables suggests that this test may be limited as a monitoring tool within this setting. This is not at all surprising considering recent evidence has emerging to suggest that the underlying mechanisms of fatigue are task-specific [14]. The results of this analysis would, therefore, support this notion, and suggest that when implementing a testing program to monitoring changes in NMF status in a predominantly running based sport, a greater task-specific test, like the SRT, may be a more useful measure. Nonetheless, a CMJ can still be a viable option within this environment, with

PV recommended as the variable to monitor due to its ability to detect practically meaningful changes in physical performance. Yet, it must also be noted that this study only utilised ARF players and results may not be indicative of all running based team sport athletes. It is, therefore, recommended that future research should look at including different running-based team sport athletes to confirm these findings.

Practical Application

From a practical perspective, it was shown that a SRT might be a more useful monitoring tool than a CMJ test in predominantly running based team sports such as ARF, due to its enhanced capability of detecting practically meaningful changes in performance. However, when utilising a CMJ test within this environment, is it recommended to monitor PV due to its enhanced ability to detected practically important changes compared to other CMJ variables. Nonetheless, when implementing either test, including at least three trials is suggested in order to reduce the estimated error and maintain the practicality within these settings.

Conclusion

In conclusion, the results suggest that both the CMJ test and SRT offer a useful and reliable measure for monitoring fatigue in high-performance ARF players with CVs observed less than 10%. However, it was determined that a SRT might provide a more useful measure when monitoring changes in NMF status due to its enhanced ability to detected practically meaningful changes in performance. Nevertheless, a CMJ test still offers a viable option within this environment, with PV recommended as the variable to monitor. To confirm these findings, future research should also look at including more running-based team sport athletes.

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Table 1. Mean ± SD and typical variation estimates represented as CVs (± 90% confidence interval) for each performance measure. The SWC is also present for comparison with estimates of typical variation. Abbreviations: CV, coefficients of variation; SWC, smallest worthwhile change; AU, arbitrary unit; PL, player load; Fwd, Forward.

	mean	CV%	SWC (%)
CMJ_H (m)	0.43 ± 0.05	6.6 (5.3;8.9)	1.1
Peak Velocity (m/s)	3.42 ± 0.31	6.8 (5.4;9.2)	7.9
Eccentric Displacement (m)	0.61 ± 0.13	12.8 (10.2;17.2)	3.2
$PL1D_{up}$ (AU)	2.69 ± 0.41	9.3 (7.4;12.5)	10.2
$PL1D_{side}$ (AU)	1.84 ± 0.28	6.7 (5.3;9.0)	7.0
$PL1D_{fwd}$ (AU)	2.28 ± 0.43	9.2 (7.4;12.5)	10.8

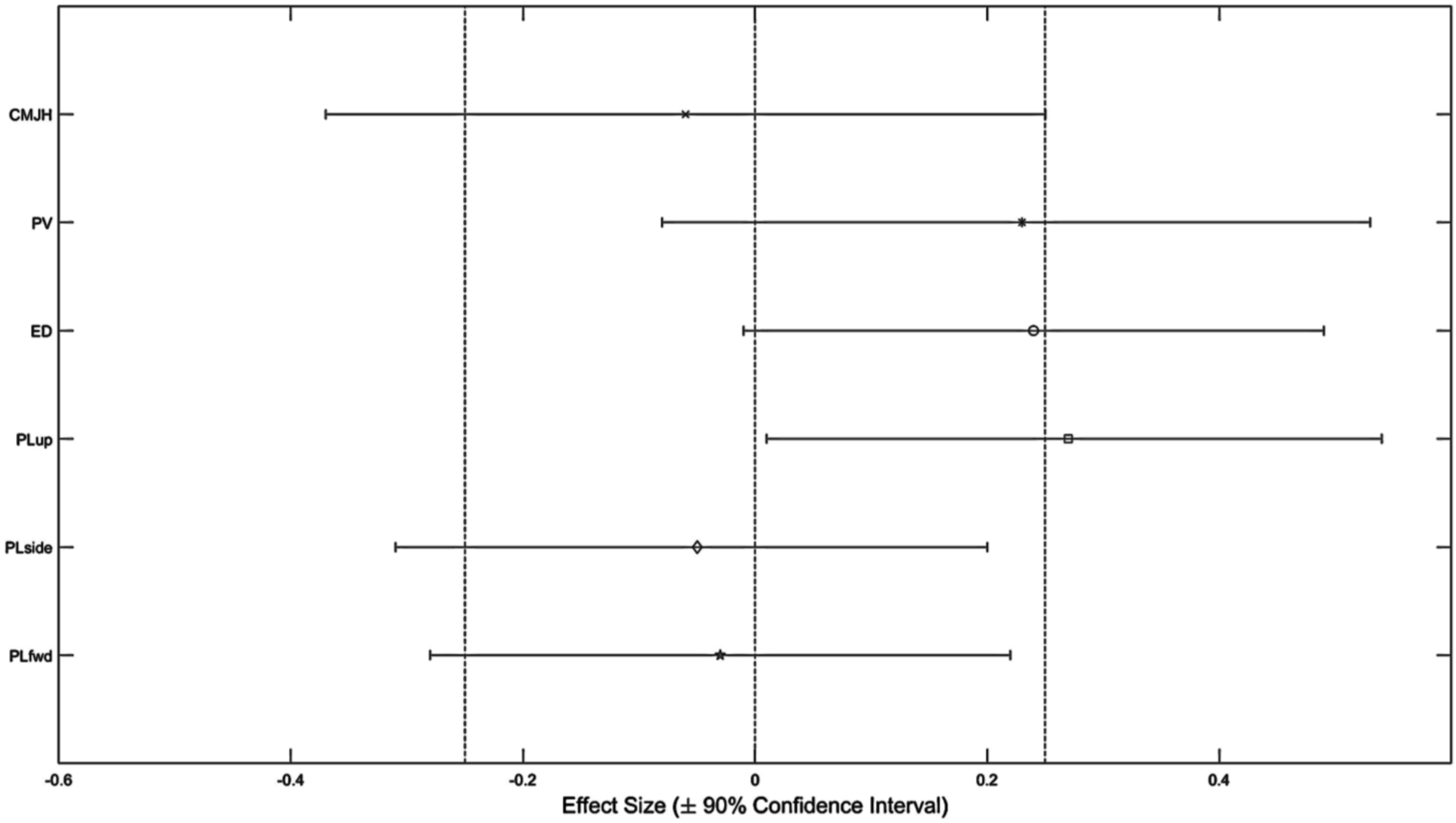

Figure 1. Mean changes in variables from week-to-week represented as an effect size (± 90% confidence interval). Vertical lines represent a small (0.25) effect size both positively and negatively and effect size at 0. Where the 90% CI simultaneously overlapped the smallest important ES (0.25) the magnitude of the difference was considered "*unclear*", with a <75% likelihood of exceeding the smallest important ES (0.25) classified as trivial (for example $PL1D_{up}$). Abbreviations: CMJ height, CMH_H; peak velocity, PV; eccentric displacement, ED; player load 1D up, $PL1D_{up}$; player load 1D side, $PL1D_{side}$; player load 1D forward, $PL1D_{fwd}$.

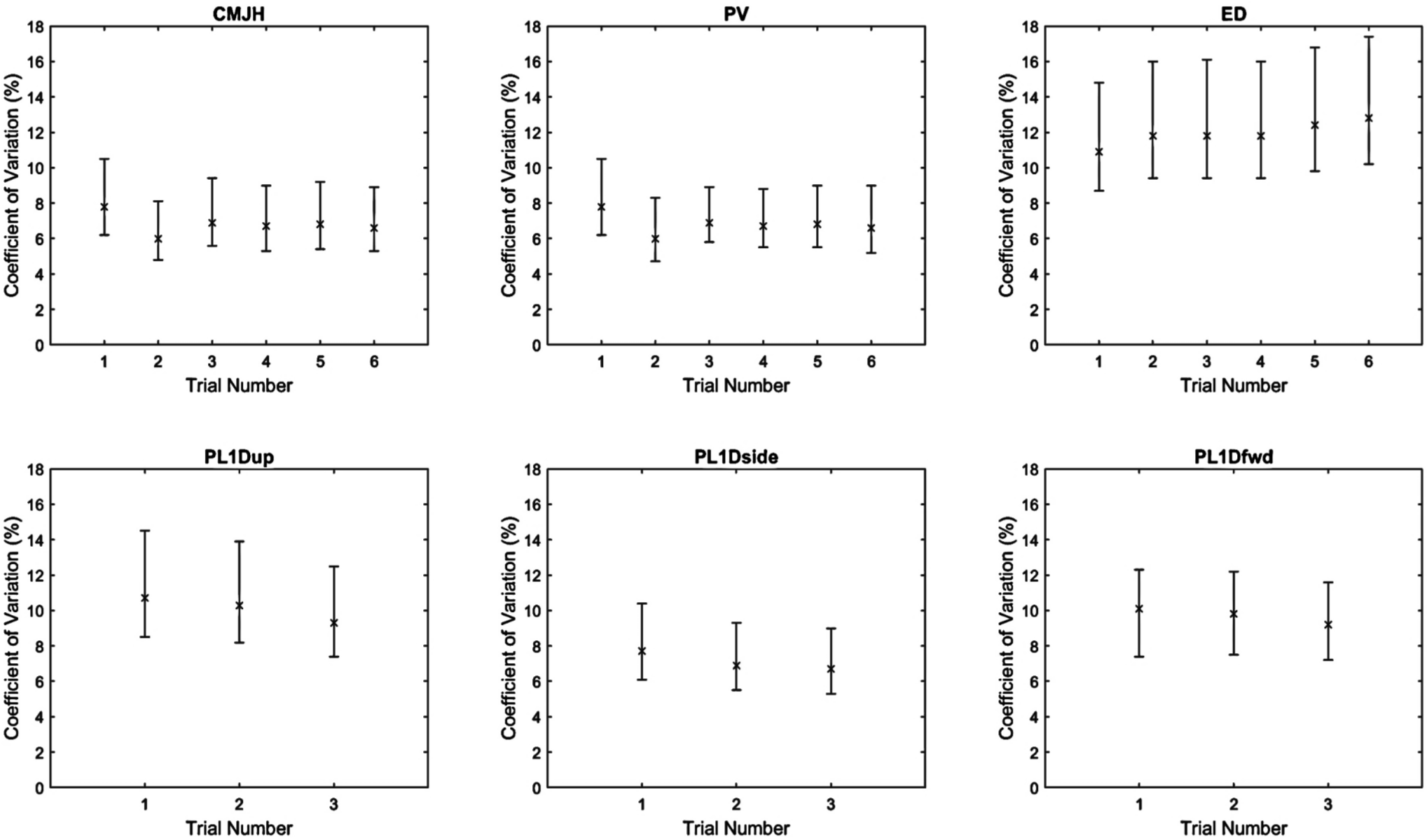

Figure 2. Mean coefficients of variation ± 90% confidence intervals for CMJ height (CMH_H), peak velocity (PV), eccentric displacement (ED), player load 1D up ($PL1D_{up}$), player load 1D side ($PL1D_{side}$) and player load 1D forward ($PL1D_{fwd}$) and the number of trials performed.