Test- Re- Test Reliability and Normative Values of Neuromuscular Performance Tests in U-18 and U-23 English Premier League Academy Football Players. Part 1: Countermovement Jump Measures.

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Abstract

Purpose: To examine the test- re- test reliability and normative values of CMJ measures in elite-level U-18 and U-23 academy football players. *Methods:* 36 players performed 3 CMJ tests on dual force plates on two separate test days ('test' and 're-test') 7 days apart across consecutive in-season microcycles. 101 variables were analysed, of which 34 were identified as principle measures, based on use in previous research and practice. Relative (ICC, ± 95% CI) and absolute (CV%, SEM and MDC) reliability were analysed for three methods: $Best_{JH}$, $Mean_{JH}$ and within-session. *Results*: Overall, relative reliability was *good* to *excellent* for $Best_{JH}$ and $Mean_{JH}$ and *moderate* to *excellent* for within-session. 27 ($Best_{JH}$ and within-session) and 28 ($Mean_{JH}$) of the 34 principle variables had *good* absolute reliability (CV% < 10%). Overall, force and power measures had better reliability than velocity, RFD and impulse measures, but absolute force measures had strong correlations with body weight, which effected reliability. *Conclusions:* Both $Best_{JH}$, and $Mean_{JH}$ methods can be used reliably for CMJ monitoring purposes in these cohorts. Of the most widely used variables in research and practice, eccentric deceleration RFD had a high MDC (~60%), which might render it unsuitable for detecting subtle changes to movement strategy or neuromuscular status in young football players. Conversely, eccentric duration and FT:CT had lower MDC values (~ 20%), supporting their use in practice. Practitioners should use relative- as opposed to absolute- force measures. Collectively, these results can be used to inform decisions relating to CMJ variable selection in practice.

Key Words

Minimal Detectable Change, Neuromuscular Fatigue, Athlete Monitoring, Force Plate, Ground Reaction Force

Introduction

The countermovement jump (CMJ) and isometric tests of posterior chain (IPCS), hip abductor (IABS) and hip adductor (IADS) strength are routinely used to profile neuromuscular capacity and detect changes to neuromuscular status in football players [1-7]. Recent advancements to the portability of diagnostic equipment and automation of force – time curve analysis have increased the popularity of these tests in practice [8]. Indeed, periodic CMJ testing is compulsory for English Premier League (EPL) affiliated academies according to Elite Player Performance Plan (EPPP) regulations, and previous research points to CMJ testing as the most commonly used response- to- load measure in football [1].

Positive correlations are consistently reported between CMJ performance measures and sprint acceleration, maximal running velocity, and change of direction performance [9,10]. For example, McFarland and colleagues [10] reported *moderate* correlations between CMJ performance and 10 m speed, 30 m speed and change of direction (COD) performance in young football players. Findings were attributed to the contributary effects that stretch shortening cycle qualities exert on both CMJ and sport-specific speed performance. Therefore, it could be surmised that changes to CMJ performance can give rise to similar changes to speed and COD performance [9]. Consequently, CMJ measures are widely used to profile neuromuscular performance and inform decisions relating to physical performance programming in young football players [5].

CMJ measures are also used to signal neuromuscular fatigue (NMF; i.e., specific reduction to the maximal force generating capacity of muscle) in practice. Indeed, reductions to CMJ performance are reported to manifest for ~ 72 h following elite-level U-18 [4,6,11], and senior professional [2,12] football match play. Time-dependent CMJ measures are considered to be particularly useful for this purpose because NMF is reported to induce changes to movement strategy independent of changes to jump height (JH) [3,13,14]. For example, perturbations to JH and flight time: contraction time ratio (FT:CT) are reported following football [6] and Australian Football (AFL) [13] training and match play, but greater and longer-lasting changes are reported to FT:CT [6,13]. Consequently, the CMJ is widely used to indicate player readiness (i.e., denoting the interplay between 'fitness' and 'fatigue' [15,16]) in practice, and inform decisions relating to training and match load planning in young football players [1,5].

Despite widespread use, no data are available to report the test- re- test reliability of CMJ, IPCS, IABS or IADS measures in EPL under 18 (U-18) and under 23 (U-23) football players. Such data will help practitioners to distinguish between meaningful adaptive and maladaptive changes to neuromuscular performance and the natural variability associated with these tests [8]. This, in-turn, will facilitate improved decision making relating to player performance programming and training and match load planning. Moreover, no published normative data are available for these tests in these cohorts. Accordingly, the aims of this investigation were to examine the test- re- test reliability and normative values for these measures in U-18 and U-21 EPL academy football players. Part 1, herein, examines CMJ measures, and part 2 examines isometric strength measures.

Methods

Study Design

Thirty-six players from the U-18 (*n* = 20, age = 17.0 ± 0.7; height = 1.82 ± 0.07 m; body mass = 73.5 ± 76 kg) and U-23 (*n* = 16, age = 19.6 ± 1.2; height = 1.81 ± 0.06 m; body mass = 75.8 ± 8.1 kg) age groups from an EPL category 1 academy participated in this investigation. Testing was conducted in an environmentally controlled performance centre located at the team's training facility. To examine test-re-test reliability, players attended two testing sessions at 09:00 on consecutive Friday mornings (i.e., 'test' and 're-test' days), spanning similar single-game microcycles during the in-season period. Weekly training and match distribution and load were consistent for both weeks across the experimental period. Consistent with previous scientific research literature, we reasoned that collecting data the day before match day (MD), (i.e., MD-1) related to when player 'fatigue' was lowest during the training week [17].

Prior to all testing, players performed a standardised warm-up consisting of ~ 4 min of dynamic mobility exercises (3 X 10 m heel flicks, hamstring kicks and walking lunges with a 10 m walk recovery between repetitions), followed by three warm-up CMJ's at 60%, 80% and 100% of perceived maximal effort, separated by ~ 30 s. Test order for the CMJ, IPCS and isometric adductor and abductor strength tests were randomised for both testing dates. All players had routinely performed the monitoring tests ~ 2 times per week for at least one full competitive season and were therefore considered to be highly familiar with all testing protocols. Ethical approval was provided by the St Marys University, Twickenham, UK Human Research Ethics Committee.

Countermovement Jump

Countermovement jump testing was performed on dual force plates (ForceDecks FD4000, Vald Performance, Brisbane, AU), sampling at 1000 Hz. Force-time curves were analysed automatically using proprietary software (ForceDecks Version 2.0.8000, Vald Performance, Brisbane, AU) according to methods described previously [8,18]. Prior to statistical analysis, 34 bilateral CMJ variables (i.e., derived from the total vertical ground reaction force) were selected for analysis from the eccentric, concentric, flight and landing phases of the CMJ and included in the main results section. Variable selection was based on use in similar scientific research literature [8] and known use in practice. Reliability data for a further 67 variables (101 variables in total, including 70 bi-lateral, 31 unilateral variables, and 5 ‘asymmetry’ variables are available in a supplementary file *(***INSERT LINK TO SUPPLEMENTARY FILE 1 HERE* ***).

Prior to each testing day, a known weight (20 kg) was used to test the accuracy of force measurement, with ± 0.1 kg considered to be a good level of measurement error [8]. The force plates were zeroed prior to all measures. Each player was asked to stand still on the force plates with their hands on their hips for ~ 5 s until a stable body mass was recorded prior to jumping. Players then performed three maximal CMJ trials, each separated by ~ 15 s. They were required to keep their hands on their hips for the entirety of each jump and were cued to 'jump maximally: as high as they could and to land on the force plates' as per previous scientific research [8]. Players were then asked to reposition their feet between repetitions. All jump testing was conducted by the same experienced practitioner. In cases where a measurement error was observed (i.e., 'tucking' or 'piking' the legs during the flight phase, a double contact prior to jumping, or if they did not land on the force plates), data were omitted, and the player was asked to perform another repetition.

Statistical Analysis

Descriptive statistics (means, 95% confidence intervals (CI), ± standard deviation (SD)) were calculated at U-18, U21 and combined group (i.e., U-18 and U-21 players combined) levels. Reliability was examined using three methods: single output for each variable taken from the trial with the best jump height ($Best_{JH}$), mean output for each variable taken from the mean of three trials ($Mean_{JH}$) and within-session. The assumption of normality was examined using the Shapiro-Wilk test. Heteroscedasticity was examined using Pearson's correlation coefficient and systematic bias between 'test' and 're-test', was examined using a paired samples *t*-test. Relative reliability was examined using intra-class correlation coefficients (ICC) as previously described [19,20] and reported with 95% CI. The ICC were interpreted as: *poor* = < 0.50; *moderate* = 0.50 – 0.74; *good* = 0.75 – 0.89 and *excellent* = > 0.9 [21]. Absolute reliability was examined using coefficient of variation (CV; %), standard error of measurement (SEM; SD $\sqrt{}$ 1-ICC), and minimal detectable change (MDC; SEM*1.96* $\sqrt{}$ 2) [22] methods. Consistent with previous scientific literature, we applied an arbitrary threshold of <

10% to define a CV as *good* [23]. Finally, a Pearson's R correlation was used to examine the correlation between body weight and each CMJ variable. All statistical tests were conducted in *R* (version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria).

Results

Descriptive Statistics

Descriptive statistics for CMJ variables for U-18, U-21, combined age group and goalkeeper groups are presented in table 1, below. Overall, there was a trend for force-dependent, time- dependent and performance- orientated CMJ variables to improve with training age and for greater jump performance measures in goalkeepers.

**** INSERT TABLE 1 HERE****

Relative Reliability

Of the 34 principle CMJ variables analysed, 6 and 28 variables had *good* and *excellent* relative reliability for both the $Best_{JH}$ (ICC range = 0.20) and $Mean_{JH}$ (ICC range = 0.17) methods and 4, 15 and 15 variables had *moderate*, *good* and *excellent* within-session (ICC range = 0.38) reliability respectively (Table 1).

Absolute Reliability

Of the 34 principle CMJ variables analysed 27 variables had CV's < 10% using the $Best_{JH}$ (CV range = 23.4%), and within-session (CV range = 51.6%) methods; and 28 variables had CV's < 10% using the $Mean_{JH}$ (CV range = 24.6%) method (Table 2). There was a trend for higher CVs using the within-session method.

*** *INSERT TABLE 2 HERE* ***

Overall there was a trend for absolute force- dependent variables to correlate more strongly with player body weight (*supplementary file 1*).

Discussion

To the authors knowledge this is the first investigation to examine the test-re-test reliability and normative data for a broad spectrum of widely used CMJ measures in elite-level U-18 and U-23 EPL academy football players. This provides researchers and practitioners alike with an ecologically valid resource to help inform CMJ variable-selection for performance and longitudinal monitoring purposes.

The first aim of this investigation was to examine the test- re- test reliability of CMJ variables for elite-level U-18 and U-23 EPL academy football players. Reliability was examined using three methods: $Best_{JH}$, $Mean_{JH}$, and within-session. Overall, we report *moderate* to *excellent* relative reliability and *good* absolute reliability for the 34 principle CMJ variables using these methods (Table 2). The second aim was to report the normative CMJ variable data for the U-18, U-23, combined (i.e., U-18 + U-23) and goalkeeper sub-groups (Table 1). Unsurprisingly we observed a trend for CMJ measures to improve with age (i.e., U-23 > U-18). For example, on average, concentric peak force, eccentric peak force, peak power, concentric duration, eccentric duration, eccentric deceleration RFD and jump height measures were greater for the U-23 group than the U-18 group (Table 1). Goalkeepers demonstrated the greatest jump height performance, which is likely explained by position-specific factors (i.e., the jump-dominant demands of goalkeeper training and match play) giving rise to more advanced neuromuscular adaptations that serve to improve jump capabilities. Indeed, on average, mean concentric power was higher for goalkeepers than outfield players, which likely contributes to this finding (Table 1).

Importantly, we report similarly high levels of relative and absolute reliability using both the $Best_{JH}$ and $Mean_{JH}$ methods. Most principle CMJ variables demonstrated *good* to *excellent* relative reliability and *good* absolute reliability using these methods (Table 2). Nonetheless, there are some subtle differences between our findings and those reported previously [3,8]. Recently, Howarth and colleagues [8] examined the interday reliability of similar CMJ variables in senior professional Rugby Union players and reported better absolute reliability for the $Mean_{JH}$ method than the $Best_{JH}$ method. Moreover, the absolute reliability of CMJ variables herein appear to be slightly lower than what has been reported previously [3,8]. Though discrepancies between our findings and others might be explained by sport related differences between cohorts, it is likely that several other factors contribute. For example, Wren and colleagues [24] reported a reduction to CMJ kinematic variability with increasing training age in young athletes, and Nibali and colleagues [25] reported a reduction in the variability of jump kinematics with increased performance level (i.e., professional athletes > college athletes > high school athletes). Consequently, it is possible that senior professional and older athletes examined previously [3,8] exhibit less movement and performance variability during the CMJ than the younger athletes examined herein. Indeed, these factors might help to explain the better absolute reliability reported previously [3,8] and why relative reliability was typically lowest for the within-session method herein (Table 2). Notwithstanding, our results indicate efficacy for both the $Best_{JH}$ and $Mean_{JH}$ methods in U-18 and U-23 EPL academy football players.

Several variables relating to CMJ movement strategy have demonstrated merit in signalling NMF [13,26], chronic adaptations to training [27,28], deceleration ability [29] and have been shown to relate to previous injury [30] in football players. Of these measures, eccentric deceleration RFD, eccentric duration and FT:CT have received particular research attention and consequently, are now widely used in practice [8]. Consistent with similar investigations [3,8,25] we report *good* to *excellent* relative reliability for these variables and CV's of ~ 8% (FT:CT and eccentric duration) and ~ 22% (eccentric deceleration RFD). Recent scientific literature suggests that variables with low absolute reliability might have merit in practice if the stimulus (i.e., football match play) results in a change to the variable that is greater than the associated CV [8]. To that end, we encourage practitioners to consider the MDC statistic when selecting CMJ variables (Table 2). For example, despite having *excellent* relative reliability, we report an MDC of ~ 60% for eccentric deceleration RFD which might render it unsuitable for detecting subtle changes to neuromuscular status in young football players. Comparatively, we report MDC's closer to 20% for eccentric duration and FT:CT, which likely makes them more suitable for this purpose (Table 2).

A novel aspect of this investigation is that we examined the correlation between CMJ variables and body weight. Overall, we observed strong correlations between absolute force variables and body weight and weak correlations between relative force- and time dependent- variables and body weight (*supplementary file 1*). For example, absolute eccentric mean force had *good* to *excellent* reliability and a *perfect* correlation (r = 1.00) with body weight. Conversely, relative eccentric mean force had *good* to *excellent* reliability and a weak correlation (r = 0.13) with body weight. Interestingly, adjusting mean eccentric force from absolute to relative terms changed the ICC from second highest of 101 variables (0.99; *excellent*) to second lowest (0.70; *moderate*). Consequently, it appears that body weight exerts an important effect on the reliability of force- dependent measures. Indeed, though we report that most absolute force variables are highly reliable, a large component of this reliability might be explained by the contribution of body weight alone. Accordingly, on balance and to ensure reliability, we advocate the use of relative as opposed to absolute force dependent CMJ measures in practice.

Practical Applications

CMJ variable selection should be based on a number of factors including relative and absolute reliability, MDC and conceptual efficacy [5]. Indeed, chosen variables should have a sound biological basis that theoretically links what is being measured to a desirable performance outcome, and / or be sensitive to training- and match- load [5,15,16]. We have reported the reliability and MDC for a wide range of CMJ variables that practitioners can use to inform variable selection. However, it is beyond the scope of this investigation to examine their conceptual efficacy. Therefore, we encourage practitioners to review the scientific literature examining the typical magnitude of change for CMJ variables following football training and / or match play. This can then be considered alongside the MDC values presented herein to support decision making relating to variable selection. To that end, we note the need for further scientific research of this type in elite-level young football players and suggest that future research examines the acute (i.e., pre- to- post- match) and longitudinal (i.e., cross-season) changes to CMJ variables in these cohorts to help in this regard.

Based on the work of Cormack and colleagues [23], we applied an arbitrary threshold of 10% to define absolute reliability but acknowledge that higher CV's might be acceptable for measures that are particularly sensitive to changes in neuromuscular status [8]. Overall, consistent with previous work [23], we consider 10% to be a useful threshold when the objective is to detect subtle day- to- day changes to neuromuscular status [23] (i.e., for longitudinal player monitoring [13,26]). Again, to help in this regard, we encourage practitioners to consider the MDC statistic to support CMJ variable selection.

Unfortunately, we only examined male players and acknowledge that our findings are not generalisable across female cohorts. As such, we encourage similar research to be urgently conducted in equivalent female cohorts.

Conclusion

Widely used CMJ variables typically have *moderate* to *excellent* relative reliability and *good* absolute reliability using the $Best_{JH}$, $Mean_{JH}$ and within-session methods in elite-level young football players. Overall, force- and power- orientated measures have better reliability than velocity-, RFD- and impulse- orientated measures. However, force- dependent measures correlate very strongly with body weight, which appears to effect reliability. Consequently, practitioners are advised to use relative as opposed to absolute force measures. Of the commonly used movement strategy variables in practice, eccentric deceleration RFD might be limited by low absolute reliability and a large MDC. Finally, practitioners are reminded to consider the conceptual basis of measures alongside these reliability data to make better informed decisions relating to variable selection.

Declarations

All authors report that they have no conflicting interests.

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Table 1, Descriptive statistics for countermovement jump (CMJ) variables for U-18, U-23, Combined (U-18 + U-23) and Goalkeeper groups. Data are presented as Mean, 95% confidence intervals (CI) ± standard deviation (SD). *Abs*; absolute; *Con*, concentric; *CT*, contraction time; *CM*, countermovement; *Dec*, deceleration; *Dur*, duration; *Ecc*, eccentric; *FT*, flight time, *FT: CT*, flight time: contraction time; *F*, force; *Imp*, impulse; *IM*, impulse momentum; *Mvt*, movement; *P*, power; *Rel*, Relative; *RFD*, rate of force development; *RSI*, reactive strength index; *V*, velocity.

CMJ Variable	**U-18** *(n = 20)*	**U-23** *(n = 16)*	**Combined** *(n = 36)*	**Goalkeepers** *(n = 6)*
Body Weight (N)	728 (691 - 764) ± 82	733 (698 - 768) ± 71	730 (705 - 755) ± 76	806 (756 - 855) ± 62
CM Depth (cm)	-32.7 (-35.7 - -29.7) ± 6.9	-30.3 (-34 - -26.6) ± 7.6	-31.5 (-33.9 - -29.2) ± 7.2	-39.8 (-44.7 - -34.8) ± 6.2
Con Dur (ms)	253 (236 - 269) ± 38	228 (210 - 247) ± 38	241 (228 - 253) ± 39	265 (244 - 285) ± 26
Con Imp 100ms (N.s)	109 (95 - 124) ± 33	129 (110 - 148) ± 38	119 (107 - 131) ± 37	113 (97 - 129) ± 20
Con Mean F (N)	1562 (1440 - 1685) ± 280	1705 (1559 - 1851) ± 298	1634 (1538 - 1729) ± 293	1726 (1568 - 1884) ± 197
Con Mean P (W)	2313 (2110 - 2515) ± 462	2572 (2283 - 2861) ± 589	2442 (2267 - 2618) ± 537	2641 (2278 - 3004) ± 453
Con Peak F (N)	1979 (1816 - 2143) ± 373	2173 (1948 - 2399) ± 461	2076 (1938 - 2215) ± 424	2116 (1973 - 2258) ± 178
Con Peak V (m/s)	2.82 (2.77 - 2.87) ± 0.12	2.85 (2.75 - 2.96) ± 0.22	2.84 (2.78 - 2.89) ± 0.17	2.94 (2.76 - 3.11) ± 0.21
Ecc Braking Imp (N.s)	67.6 (61.9 - 73.3) ± 13.1	73.5 (64.4 - 82.6) ± 18.6	70.6 (65.3 - 75.8) ± 16.1	90.5 (79.3 - 101.7) ± 14
Ecc Dec RFD Abs. (N/s)	8533 (6569 - 10497) ± 4481	11879 (8072 - 15687) ± 7771	10206 (8096 - 12317) ± 6461	8520 (7419 - 9621) ± 1376
Ecc Dec RFD Rel. (N/s/Kg)	7.25 (6.89 - 7.6) ± 0.8	7.37 (6.75 - 7.99) ± 1.26	7.31 (6.97 - 7.65) ± 1.04	8.6 (7.98 - 9.22) ± 0.78
Ecc Dur (ms)	479 (444 - 514) ± 80	423 (394 - 453) ± 60	451 (427 - 476) ± 75	480 (412 - 547) ± 85
Ecc Mean Braking F (N)	1007 (926 - 1089) ± 186	1079 (996 - 1162) ± 169	1043 (985 - 1101) ± 178	1168 (1056 - 1280) ± 140
Ecc Mean F (N)	729 (693 - 765) ± 83	734 (699 - 770) ± 72	732 (707 - 757) ± 76	807 (758 - 857) ± 62
Ecc Mean P Abs. (W)	536 (503 - 569) ± 75	546 (507 - 585) ± 80	541 (516 - 566) ± 76	706 (637 - 776) ± 87
Ecc Mean P Rel. (W/Kg)	7.25 (6.89 - 7.6) ± 0.8	7.37 (6.75 - 7.99) ± 1.26	7.31 (6.97 - 7.65) ± 1.04	8.6 (7.98 - 9.22) ± 0.78
Ecc Peak F (N)	1924 (1741 - 2106) ± 417	2156 (1911 - 2400) ± 499	2040 (1887 - 2192) ± 467	2112 (1964 - 2260) ± 185
Ecc Peak V (m/s)	-1.28 (-1.36 - -1.2) ± 0.18	-1.39 (-1.49 - -1.3) ± 0.19	-1.34 (-1.4 - -1.27) ± 0.19	-1.6 (-1.7 - -1.5) ± 0.13
Ecc: Con Mean F	48.2 (46.4 - 50) ± 4.1	45 (42.4 - 47.6) ± 5.3	46.6 (45 - 48.2) ± 4.9	48.4 (46.4 - 50.3) ± 2.4
Ecc: Con Peak P	0.46 (0.42 - 0.5) ± 0.1	0.56 (0.41 - 0.71) ± 0.3	0.51 (0.43 - 0.58) ± 0.23	0.59 (0.43 - 0.76) ± 0.21
F at Peak P Abs. (N)	1655 (1535 - 1776) ± 275	1829 (1669 - 1989) ± 326	1742 (1641 - 1843) ± 309	1824 (1664 - 1983) ± 200
F at Peak P Rel. (N/Kg)	1.27 (1.18 - 1.36) ± 0.21	1.49 (1.32 - 1.66) ± 0.35	1.38 (1.28 - 1.48) ± 0.3	1.26 (1.16 - 1.36) ± 0.13
F at Zero V (N)	1910 (1731 - 2088) ± 407	2094 (1874 - 2314) ± 448	2002 (1861 - 2143) ± 431	2072 (1921 - 2223) ± 189
FT (ms)	562 (546 - 578) ± 37	582 (564 - 600) ± 37	572 (560 - 584) ± 38	603 (567 - 639) ± 44
FT: CT	0.72 (0.66 - 0.77) ± 0.12	0.87 (0.8 - 0.94) ± 0.14	0.79 (0.74 - 0.84) ± 0.15	0.77 (0.69 - 0.85) ± 0.1
JH - FT (cm)	38.9 (36.6 - 41.1) ± 5.1	41.7 (39.1 - 44.3) ± 5.3	40.3 (38.5 - 42) ± 5.3	44.8 (39.7 - 49.9) ± 6.4
JH - IM (cm)	37.7 (36.3 - 39.2) ± 3.4	39 (36 - 42) ± 6.1	38.4 (36.8 - 40) ± 4.9	41.3 (36.3 - 46.2) ± 6.2
Landing RFD (N/s)	117224 (90548 - 143901) ± 60870	82289 (70087 - 94491) ± 24902	99757 (83741 - 115772) ± 49028	259958 (20132 - 499784) ± 299726
Mvt Start to Peak F (s)	0.6 (0.55 - 0.65) ± 0.11	0.49 (0.44 - 0.53) ± 0.1	0.54 (0.51 - 0.58) ± 0.12	0.54 (0.36 - 0.72) ± 0.22
Mvt Start to Peak P (s)	0.73 (0.67 - 0.78) ± 0.13	0.61 (0.57 - 0.66) ± 0.09	0.67 (0.63 - 0.71) ± 0.12	0.73 (0.62 - 0.84) ± 0.14
Peak Landing F (N)	4328 (3829 - 4826) ± 1138	3779 (3391 - 4167) ± 792	4053 (3726 - 4381) ± 1003	5244 (3813 - 6676) ± 1789
Peak P Abs. (W)	4038 (3752 - 4325) ± 654	4365 (3929 - 4801) ± 890	4202 (3945 - 4458) ± 785	4766 (4096 - 5436) ± 837
Peak P Rel. (W / kg)	54.38 (52.07 - 56.69) ± 5.26	58.32 (53.58 - 63.06) ± 9.68	56.35 (53.76 - 58.94) ± 7.91	57.72 (52.36 - 63.07) ± 6.69
RSI Modified	0.55 (0.51 - 0.59) ± 0.09	0.67 (0.6 - 0.74) ± 0.15	0.61 (0.56 - 0.65) ± 0.14	0.64 (0.56 - 0.72) ± 0.1

Table 2, $Best_{JH}$, $Mean_{JH}$ and Within-Session reliability of countermovement jump (CMJ) variables. Data are presented as relative reliability: *ICC*, intraclass correlation coefficient (± 95% CI) and absolute reliability: *CV*, coefficient of variation; *SEM*, standard error of measurement and *MDC%*, minimal detectable change (percent). *Abs*; absolute; *Con*, concentric; *CT*, contraction time; *CM*, countermovement; *Dec*, deceleration; *Dur*, duration; *Ecc*, eccentric; *FT*, flight time, *FT: CT*, flight time: contraction time; *F*, force; *Imp*, impulse; *IM*, impulse momentum; *Mvt*, movement; *P*, power; *Rel*, Relative; *RFD*, rate of force development; *RSI*, reactive strength index; *V*, velocity.

	Best$_{JH}$		Mean$_{JH}$		Within-Session	
CMJ Variable	**ICC (95% CI)**	**CV; SEM; MDC%**	**ICC (95% CI)**	**CV; SEM; MDC%**	**ICC (95% CI);**	**CV; SEM; MDC%**
Body Weight (N)	0.99 (0.99 – 1.00)	1.1; 7.84; 2.9	0.99 (0.99 – 1.00)	1.1; 7.84; 2.9	1.00 (1.00 – 1.00)	0; 0; 0
CM Depth (cm)	0.93 (0.88 - 0.96)	-8.3; 2.74; -23.1	0.93 (0.88 - 0.96)	-8.3; 2.74; -23.1	0.83 (0.65 - 0.91)	-8; 2.62; -22.1
Con Dur (ms)	0.95 (0.91 - 0.97)	5.1; 12.5; 14.2	0.95 (0.91 - 0.97)	5.1; 12.5; 14.2	0.86 (0.76 - 0.92)	5.8; 14.3; 16.2
Con Imp 100ms (N.s)	0.96 (0.92 - 0.97)	8.7; 10.1; 24	0.96 (0.94 - 0.98)	8; 8.8; 22.3	0.92 (0.88 - 0.95)	9.2; 10; 25.6
Con Mean F (N)	0.98 (0.96 - 0.99)	3.7; 61.6; 10.4	0.98 (0.97 - 0.99)	3.2; 51.1; 8.9	0.96 (0.93 - 0.98)	3.4; 53.4; 9.3
Con Mean P (W)	0.96 (0.93 - 0.98)	6.2; 150; 17.2	0.96 (0.93 - 0.98)	6; 141; 16.7	0.95 (0.92 - 0.97)	5.1; 117; 14
Con Peak F (N)	0.95 (0.92 - 0.97)	6.1; 126; 16.8	0.97 (0.94 - 0.98)	4.8; 96; 13.3	0.93 (0.90 - 0.96)	5.2; 105; 14.4
Con Peak V (m/s)	0.83 (0.70 - 0.90)	3.5; 0.1; 9.8	0.83 (0.71 - 0.91)	3.7; 0.1; 10.2	0.87 (0.81 - 0.92)	2.4; 0.07; 6.6
Ecc Braking Imp (N.s)	0.91 (0.85 - 0.95)	10.7; 7.84; 29.7	0.93 (0.88 - 0.96)	10.2; 6.54; 28.4	0.62 (0.47 - 0.75)	18.4; 11.69; 50.9
Ecc Dec RFD Abs. (N/s)	0.95 (0.92 - 0.97)	20.5; 1995; 56.9	0.96 (0.93 - 0.98)	18.5; 1579; 51.2	0.92 (0.87 - 0.95)	21.8; 1876; 60.5
Ecc Dec RFD Rel. (N/s/Kg)	0.95 (0.92 - 0.97)	21.9; 2.61; 60.8	0.96 (0.93 - 0.98)	20.2; 2.1; 56.1	0.92 (0.87 - 0.95)	23.5; 2.45; 65.2
Ecc Dur (ms)	0.88 (0.78 - 0.93)	8.1; 37.5; 22.5	0.88 (0.78 - 0.93)	8.1; 37.5; 22.5	0.82 (0.73 - 0.89)	8.5; 39.1; 23.7
Ecc Mean Braking F (N)	0.95 (0.92 - 0.97)	5.1; 53.9; 14.2	0.96 (0.93 - 0.98)	4.3; 43.3; 12	0.84 (0.75 - 0.90)	6.5; 65.3; 18
Ecc Mean F (N)	0.99 (0.99 – 1.00)	1.1; 7.88; 2.9	1.00 (0.99 – 1.00)	1; 7.73; 2.9	1.00 (1.00 – 1.00)	0.1; 0.91; 0.3
Ecc Mean P Abs. (W)	0.93 (0.88 - 0.96)	6.3; 36; 17.6	0.92 (0.85 - 0.95)	7.1; 37.8; 19.8	0.75 (0.55 - 0.86)	7.6; 40.5; 21.1
Ecc Mean P Rel. (W/Kg)	0.91 (0.84 - 0.95)	6.1; 0.45; 16.8	0.89 (0.80 - 0.94)	7; 0.49; 19.4	0.68 (0.47 - 0.81)	7.7; 0.54; 21.5
Ecc Peak F (N)	0.96 (0.93 - 0.98)	6.4; 130; 17.7	0.96 (0.93 - 0.98)	5.7; 110; 15.8	0.90 (0.83 - 0.94)	6.5; 126; 18.1
Ecc Peak V (m/s)	0.79 (0.64 - 0.88)	-10.4; 0.14; -28.7	0.89 (0.81 - 0.94)	-6.8; 0.1; -19	0.72 (0.50 - 0.84)	-7.2; 0.11; -20
Ecc: Con Mean F	0.94 (0.90 - 0.97)	3.4; 1.61; 9.4	0.94 (0.90 - 0.97)	3.4; 1.61; 9.4	0.89 (0.81 - 0.93)	3.2; 1.54; 9
Ecc: Con Peak P	0.97 (0.96 - 0.99)	9.7; 0.05; 26.8	0.97 (0.95 - 0.98)	9.9; 0.05; 27.5	0.82 (0.66 - 0.9)	15.3; 0.07; 42.3
F at Peak P Abs. (N)	0.99 (0.97 - 0.99)	2.8; 49.6; 7.8	0.98 (0.97 - 0.99)	2.9; 49; 8	0.94 (0.87 - 0.97)	3.6; 60.9; 9.9
F at Peak P Rel. (N/Kg)	0.98 (0.96 - 0.99)	4.4; 0.06; 12.2	0.97 (0.95 - 0.99)	4.7; 0.06; 13.1	0.88 (0.78 - 0.94)	6.4; 0.08; 17.8
F at Zero V (N)	0.95 (0.92 - 0.97)	6.5; 129; 17.9	0.95 (0.92 - 0.97)	6.2; 118; 17.2	0.92 (0.86 - 0.95)	6.2; 117; 17.1
FT (ms)	0.93 (0.87 - 0.96)	2.5; 14.4; 7	0.92 (0.86 - 0.96)	2.6; 14.8; 7.3	0.88 (0.82 - 0.93)	2.3; 12.8; 6.3
FT: CT	0.91 (0.84 - 0.95)	8.1; `0.06; 22.4	0.94 (0.89 - 0.97)	6.2; 0.05; 17.1	0.90 (0.85 - 0.94)	6.1; 0.05; 16.9
JH - FT (cm)	0.93 (0.87 - 0.96)	5.1; 2.06; 14.2	0.92 (0.87 - 0.96)	5.3; 2.06; 14.6	0.89 (0.83 - 0.93)	4.5; 1.76; 12.5
JH - IM (cm)	0.84 (0.73 - 0.91)	7.3; 2.72; 20.1	0.84 (0.72 - 0.91)	7.6; 2.74; 21.1	0.86 (0.80 - 0.92)	5.2; 1.85; 14.4
Landing RFD (N/s)	0.97 (0.95 - 0.98)	24.5; 31626; 67.8	0.97 (0.94 - 0.98)	25.6; 26980; 71.1	0.77 (0.67 - 0.85)	51.6; 54984; 143
Mvt Start to Peak F (s)	0.81 (0.67 - 0.89)	14.8; 0.08; 41	0.89 (0.80 - 0.93)	10.3; 0.05; 28.7	0.77 (0.67 - 0.86)	12.8; 0.06; 35.6
Mvt Start to Peak P (s)	0.87 (0.77 - 0.92)	8.9; 0.06; 24.6	0.92 (0.86 - 0.96)	6.3; 0.04; 17.6	0.85 (0.78 - 0.91)	7.2; 0.05; 19.9
Peak Landing F (N)	0.92 (0.86 - 0.95)	10.4; 444; 28.8	0.92 (0.86 - 0.95)	10.4; 444; 28.8	0.69 (0.56 - 0.80)	16.7; 708; 46.3
Peak P Abs. (W)	0.98 (0.96 - 0.99)	3.9; 165; 10.8	0.98 (0.96 - 0.99)	4.2; 172; 11.6	0.97 (0.94 - 0.98)	3.1; 126; 8.5
Peak P Rel. (W / kg)	0.95 (0.92 - 0.97)	4.2; 2.32; 11.6	0.95 (0.91 - 0.97)	4.5; 2.44; 12.5	0.94 (0.88 - 0.96)	3.2; 1.71; 8.8
RSI Modified	0.93 (0.88 - 0.96)	7.7; 0.05; 21.4	0.94 (0.89 - 0.96)	7.6; 0.04; 21.2	0.91 (0.86 - 0.94)	7; 0.04; 19.4