BILATERAL CMJ ASSYMETRIES IN YOUNG MALE ATHLETES: A STUDY ACROSS DIFFERENT AGE GROUPS AND SPORTS

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The purpose of this study was to investigate bilateral countermovement jump asymmetries on a sample of 232 male student-athletes of 10 different sports, on a cross sectional approach over one year duration. Asymmetry in a number of force-related variables during the concentric and eccentric phases of a countermovement jump was defined as the absolute difference in performance between limbs expressed as a percentage of the total performance. Thresholds based on those asymmetries' means plus standard deviations of the whole sample were set. Our study indicates that regardless of the sport, asymmetries defined in this way are more likely to occur in active boys from 13 to 15 years old.

KEY WORDS: countermovement jump, bilateral, asymmetry, concentric, eccentric

INTRODUCTION: Bilateral asymmetry (BA) is a term frequently used in the fields of rehabilitation and sport performance, describing substantial deviation from normative data or functional performance differences between limbs (Schlumberger et al.; 2006). The underlying premise is that substantial deviations create compensatory movements, modify loading patterns and may lead to injury. Whilst the theory seems plausible, limited evidence exists to substantiate the argument. Before any association with injury is established, clear criteria and thresholds need to be set in order to clinically diagnose an asymmetry, and these thresholds will be specific to the parameter of interest. In addition to this the current trend is to test athletes in functional, dynamic and closed chain movements. It is well known that counter movement jump (CMJ) is a widely accepted means of assessing explosive leg strength. Jump-height measures calculated using the impulse method from force plate (FP) are considered the most accurate and reliable (Street et al., 2001). BAs characteristics during a CMJ can be easily calculated during regular assessments of jumping height, force and power. Clinicians have generally adopted arbitrary values of around 10% to 15% but with no clear rationale or appreciation of typical differences between limbs (Impellizzeri et al., 2007; Schiltz et al., 2009; Bennell et al., 1998; Croisier et al., 2002).
The aims of this study were twofold, firstly to establish thresholds for selected parameters in order to diagnose asymmetrical performance, and secondly to profile the frequency of asymmetry with respect to age and sport within a sports academy.

METHODS: 232 healthy, male student-athletes from 11 to 17 years-old, training up to 8 times a week in 10 different sports, volunteered for the study. Their performances were tracked 4 times along a full year, totalling 514 testing sessions. The age of the subjects (in days) was calculated on the day of testing and the data allocated into the age ranges 11-13, 13-14, 14-15, 15-16 and 16-17. Group characteristics are shown in Tables 1 and 2.
All subjects performed a self-selected warm-up before the trials, including a number of practice jumps. CMJ performances were assessed on two portable FPs (Kistler type 9286AA and Bioware V5.0, Switzerland), sampling at 1000Hz and treated with a 7-point moving average filter.

Table 1
Subject's BW [kg] by Sport and Age Group [y.o.]

Sport	11-13	13-14	14-15	15-16	16-17	Averages
Athletics	57.0 ±17.8	57.1 ±16.3	63.3 ±15.0	61.0 ±16.0	62.6 ±10.5	**60.5 ±16.9**
Football	38.2 ±7.0	47.8 ±9.6	54.2 ±8.6	58.3 ±8.7	60.8 ±8.3	**52.2 ±11.2**
T. Tennis	40.5 ±8.9	41.5 ±9.2	63.0 ±8.2	67.9 ±7.8	59.9 ±0.2	**54.5 ±14.1**
Rest*	41.3 ±8.4	50.1 ±12.1	53.7 ±9.2	64.5 ±16.3	63.8 ±10.0	**50.7 ±13.2**
Averages	**41.4 ±10.2**	**50.9 ±13.2**	**57.3 ±11.6**	**60.6 ±12.5**	**61.9 ±9.1**	**55.2 ±14.4**

Table 2
Number of Sessions (population) by Sport and Age Group [y.o.]

Sport	11-13	13-14	14-15	15-16	16-17	Totals
Athletics	8	35	35	37	16	**131**
Football	37	43	54	49	35	**218**
T. Tennis	9	6	8	9	3	**35**
Rest*	42	38	24	8	18	**130**
Totals	**96**	**122**	**121**	**103**	**72**	**514**

(*): Includes fencing, golf, gymnastics, multi-sports, shooting, squash and swimming

CMJs started from a stationary position with the subjects' feet symmetrically set about shoulder width apart. CMJ trials were performed with the subjects' hands remaining on their hips throughout the whole movement. A trial was considered successful when both feet clearly landed wholly on their toes on the surface of the FPs. The FPs were zeroed before every trial, and data collection started by measuring the athletes' body weight (BW) on both FPs to ensure that they registered the same force, prior to performing 3 maximal effort jumps. Following landing, the subjects adjusted the feet position and maintained a stationary position on the FPs for at least a second before jumping; this was to ensure a reliable initial vertical velocity of 0 m/s. Results of those 3 jumps were averaged, obtaining a single representative value for every variable in the testing session. The onset of movement was automatically set to the point when the total vertical force deviated -20 [N] from body weight and the take-off (TO) was set to the point when the total vertical force dropped below 10 [N], as shown in Figure 1. Jump height was calculated using the impulse method with the total vertical force, and its first derivative was used to determine vertical velocity. The reverse point (R), the point where the vertical velocity changes from negative to positive, was used to split the movement into eccentric (Ecc) and concentric (Con) phases.

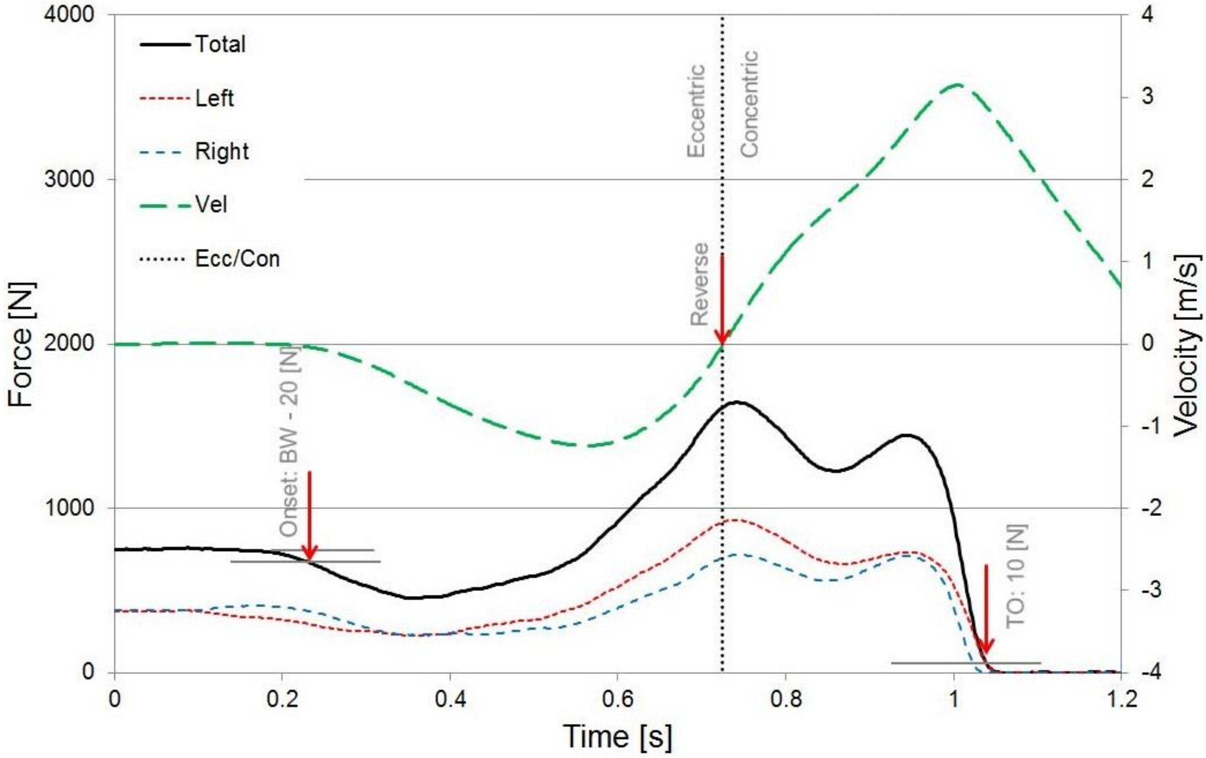

Figure 1: Typical bilateral CMJ plot showing its landmarks, vertical forces and velocity.

Three force characteristics from the left and right limbs were selected for analysis: their maximums and their averages in both the Ecc and Con phases. Bilateral asymmetries were calculated as the absolute difference between limbs' performances expressed as a percentage contribution to the total performance:

$$Asymmetry_A(\%) = \left|\frac{Performance\ A_L - Performance\ A_R}{Performance\ A_L + Performance\ A_R}\right| 100$$

where A is any of the 3 chosen force characteristics, L is left and R is right.

The asymmetries were computed for every one of the 514 samples. A threshold for each of the chosen variables was calculated to their mean plus a standard deviation of the sample, as shown in Table 3.

Table 3
Asymmetry thresholds of the sample [%]

Maximum forces	Average Ecc forces	Average Con Forces
7.55	13.01	7.73

An athlete was considered asymmetrical if one or more of the 3 variables exceeded these thresholds. An asymmetry score from 0 to 3 was calculated for every sample, as the number of times the subject exceeded the abovementioned thresholds in a single testing session.

RESULTS: The thresholds reported here are similar to those of Graham-Smith & Al-Dukhail (2014) on a different population. The average asymmetry score by sport and age group is shown in Fig. 2. Table 4 shows the number of cases with at an asymmetry score ≥1.

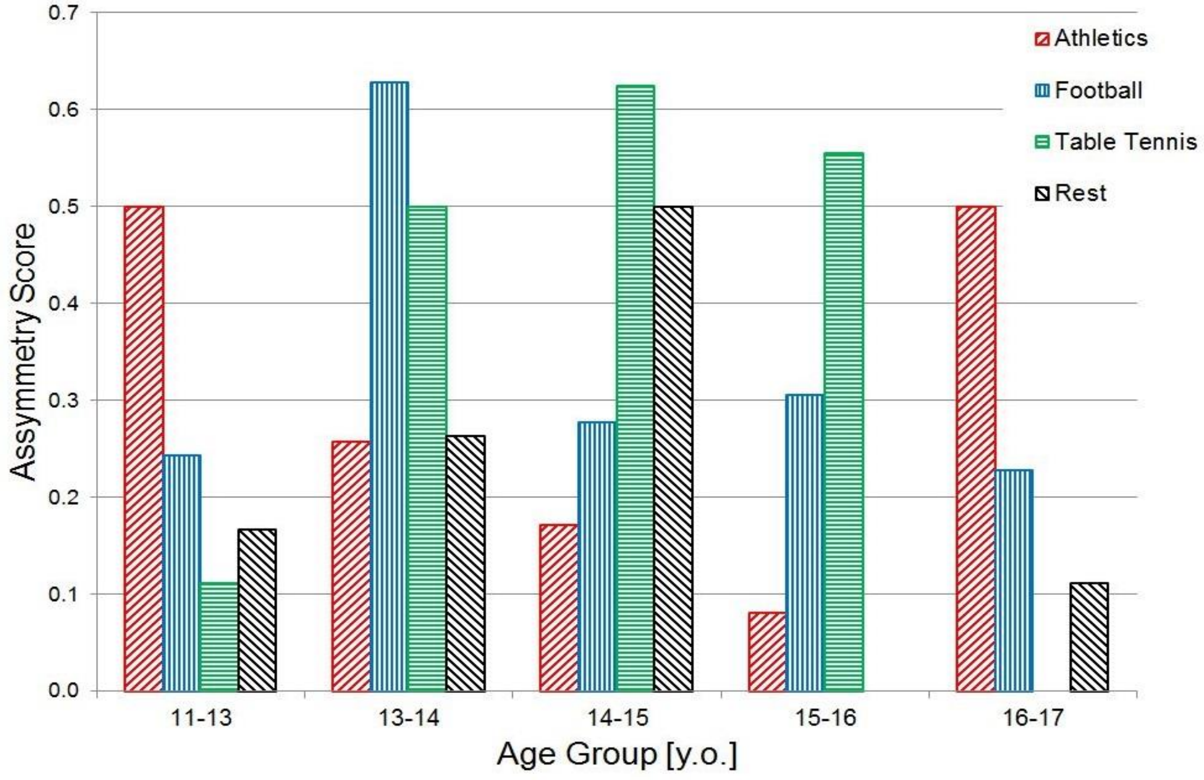

Figure 2: Average of the defined CMJ asymmetry scores across sports and age groups.

Table 4
Number of occurrencies by sport and age group [y.o.] with asymmetry score ≥ 1

Sport	**11-13**	**13-14**	**14-15**	**15-16**	**16-17**	**%**
Athletics	4	7	4	2	5	**16.8**
Football	9	13	11	8	6	**21.6**
T. Tennis	1	3	3	3	0	**28.6**
Rest	4	6	7	0	2	**14.6**
Totals	**18**	**29**	**25**	**13**	**13**	**19.1**
%	**18.8**	**23.8**	**20.7**	**12.6**	**18.1**	

DISCUSSION: The results of this study seem to suggest that regardless of the sport, asymmetries defined in this way are more likely to occur in active boys from 13 to 15 years old. This maybe due to accelerated limb growth during that age and a greater rise in body mass, which is likely to impact on coordination and motor control. Given that many sports skills in football and athletics are highly lower-limb asymmetric and dependent on the position or event, then within these periods of growth and physical development there is a need to monitor athletes for their ability to generate force. Within these years muscles and tendons are adapting to bone growth and asymmetrical loading may lead to an increased risk of growth related injuries such as Osgoods Schlatters desease. Monitoring of bilateral asymmetrical loading in CMJ routinely may help to identify potential injury risks.
Whilst this is only a cross sectional study at present, it is noteworthy that table tennis appears to consistently generate higher asymmetry scores across the 13-16 year old age group, whilst in football and athletics asymmetries appear less prevalent between 14-16.

CONCLUSION: Setting specific asymmetry thresholds based on the mean ± sd absolute difference between limbs enabled us to quantify the number of asymmetries in bilateral CMJ. Separating the performance into eccentric and concentric phases allowed us to examine specific phases of the movement as well as maximum forces, therefore providing a more thorough assessment of loading within the skill. A cross sectional approach over one year duration has revealed some interesting findings and highlighted a potentially vulnerable age span. This study now needs to be extended in order to conduct a longitudinal analysis to confirm these findings.

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