EXPLOSIVE AND REACTIVE HORIZONTAL JUMP ASSESSMENT – RELIABILITY AND VALIDITY FOR ATHLETIC POPULATIONS

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The reliability and validity of horizontal jump (HJ) kinetic measures was assessed for six female national-class track sprinters aged 15-18 years. Each sprinter performed three 10 m sprints, as well as five standing HJs and five reactive HJs from a 45 cm drop. Two Kistler force platforms (1000 Hz) covered with Mondo track surface recorded the HJ ground contact kinetics and an aluminium measuring tape was used to record HJ distance. Statistical measures included the intra-class coefficient and coefficient of variation to determine reliability of the measures. Linear regression analysis between sprint performance and the HJ measures was employed to assess validity. The standing explosive HJ test was revealed to be valid and reliable in female junior sprinters. The kinetic measures were superior to traditional field measures of jump distance.

KEYWORDS: Athletics, Sprint, Broad Jump, Kinetics, Test.

INTRODUCTION: Almost all functional athletic activities are the result of a combination of vertical, horizontal, and/or mediolateral ground reaction forces (Maulder & Cronin, 2005). These ground reaction forces enable the generation (initiation) or the continuity of highly coordinated multi-joint movement actions such as running and jumping. Despite this well known basic biomechanical theory there still remains a paucity of published research on the relationship of strength and power measures to functional performance in athletic tasks.
Isokinetic dynamometry is a widely used and abused tool in exercise and sports science. This method of testing can be valuable in isolated joint muscle function assessment in rehabilitation programs. However, it should be used with caution when assessing functional performance characteristics of athletic activities (Iossifidou, Baltzopoulos, & Giakas, 2005). Isokinetic testing is an open chain movement that is restricted to one segment and one joint. This limits the contraction of the biarticular muscles and the resulting joint angular velocity. Vertical or horizontal jump testing is a closed chain movement that can be manipulated to test different muscle activation patterns. The joint angular velocities are not restricted and therefore there is a transfer of energy between joints. Traditionally these closed chain actions have been assessed through simple field tests that measure the displacement achieved during the Sargeant (vertical jump with full arm swing) and broad jumps (Bradshaw & Le Rossignol, 2004). Through advances in portable force platform technology such as the uniaxial Kistler 'Quattro' force platform it has been revealed that various jump kinetic measures are more valid and reliable for athletic populations (e.g. Maulder, Bradshaw & Keogh, 2006).
Issues of reliability and validity should guide test selection in order to offer sound prognostic and diagnostic value to the sports science practitioner. Unilateral assessment can detect limb asymmetry (Joseph, Bradshaw, & Williams, 2007), however bilateral jump tests can be easier to administer. With portable dual-force plate systems now becoming more widely available (e.g. Kistler 9286A) the performance of each limb can be measured simultaneously to detect excessive levels of limb dominance (Lilley, Bradshaw, & Rice, 2007). The jump action administered can provide insight on different strength qualities. The countermovement jump, for example, can be used to assess leg power under slow stretch load conditions, whereas the reactive (drop) jump measures fast stretch load conditions and the stretch load strength (tolerance) of the lower extremity musculotendinous unit (Maulder & Cronin, 2005). Acyclic single jump tests are more appropriate for basic strength assessments and for isolated explosive events such as sprint starts. Whereas cyclical multiple jumping tests more accurately mimic the force and power qualities required for many athletic tasks. Both acyclic and cyclical vertical jump tests have been previously validated for assessing the kinetic

determinants of sprinting ability (Maulder et al. 2006). Whilst the reliability of horizontal jump kinetics has been demonstrated (Stalbom, Holm, Cronin, Keogh, 2007) the validity of this test relative to athletic performance has not been addressed. The purpose of current study was to establish the reliability and validity of kinetic measures of horizontal jumping and to determine whether three or five trials are required for accurate performance assessment in the field.

METHOD: Six 15-18 year old, junior national-class female sprinters (height = 1.75 ± 0.04 m; mass = 64.6 ± 5.0 kg) who were injury free at the time of testing participated in the study. Informed written consent was obtained from all athletes and their parents/guardians when under 18 years of age, prior to participation in the study. All procedures undertaken in the study were approved by the Australian Catholic University Ethics Committee.

The reliability of 10 m sprinting performance from three tests has previously been established (e.g. Moir, Button, Glaister, Stone, 2004). All participants completed three 10 m sprints from a standing start, five standing horizontal jumps, and five reactive horizontal jumps from a 45 cm box. For the reactive jumps the participants were instructed to step off the 45 cm box landing onto two feet and then to jump quickly and explosively as far as they could horizontally. The sprinting tests were recorded using Swift dual-beam timing gates (Swift Performance Technologies, 80 Hz) and the horizontal jump lengths were measured using an aluminium measuring tape. The take-off kinetics of the horizontal jumps were recorded for all trials using two portable, multicomponent force platforms operating at 1000 Hz (Kistler, 9286A, Switzerland). The upper surface of the force platforms were covered with Mondo track surface. The force/time curves for each jump were analyzed using Bioware software (Kistler, Switzerland) to identify the peak ground reaction forces and contact times (s). All force measures were normalized to units of body weight for each athlete.

The statistical procedures were performed using SPSS version 14.0 and statistical significance of $p<0.05$ was set for all analyses in the study. The critical appraisal approach was used to determine if the grouped data (mean from the first three trials and five trials) was normally distributed according to a set number of criteria following the recommendations of Peat and Barton (2005), as outlined in Bradshaw et al. (2007). All grouped data was normally distributed and therefore parametric tests were employed for the remaining statistical analysis.

Means ($\overline{X}$), standard deviations (SD), intra-class coefficients (ICC), and coefficient of variations (CV%) were calculated for all measures when taken from three trials and five trials. The intra-class coefficients were calculated from the reliability analysis function in SPSS (two-tailed mixed consistency model) whereas the coefficient of variations were calculated from the mean square error (MSE) outputted from repeated measures analysis of variance (ANOVA) using the formula; $CV\% = 100(e^{\sqrt{MSE-1}})$ (Schabort et al. 1999). The interpretation of ICC's range from 'questionable' (0.7 to 0.8), 'good' (0.8 to 0.9) and 'high' (>0.9), and an arbitrary goal of 10% or below is used to interpret 'good' reliability for the CV% (Atkinson and Nevill, 1998). It is important to acknowledge that these reliability measures include variable influences of both technological error (e.g. due to low sampling rates) and biological movement variability (Bradshaw, Maulder & Keogh, 2007). Separating these two components is arguably not necessary in reliability assessment. Reliability can decline with fatigue (Thompson, Haljand, MacLaren, 2000), limiting the number of trials that can be performed consistently, particularly in tasks that require maximal effort. There may be an optimal number of trials athletes should undertake to establish their current level of performance for a given task. Linear regression analysis was employed to examine the relationship between the measures when calculated from three trials versus five trials. Regression analysis indicates the linearity of the relationship between the one measure and the other (Bradshaw & Le Rossignol, 2004). A perfectly linear relationship is described by a coefficient (r) of 1.00 whereas no relationship is described by an R of 0. The coefficient of determination (r^2) indicates the degree of certainty in the outcome measure (five trials) that can be explained by the predictor measure (three trials). A coefficient of determination (r^2) of

0.85 indicates, for example, that 85% of the outcome measure variability for a group can be explained by the predictor measure. Once the number of trials required for a reliable test was established (mean of three or five trials) the validity of the horizontal jump measures for sprinting performance in the track and field athletes was assessed using linear regression analysis with the mean and best 10 m sprint times.

RESULTS & DISCUSSION: The mean and best 10 m sprinting performance was 2.00 $\pm$ 0.11 s (1.84 -2.12 s) and 1.97 $\pm$ 0.10 s (1.82 -2.10 s) respectively. The reliability of this measure from three trials was strong with an ICC of 0.99 and a CV% of 3.76. The results for the horizontal jump measures are summarized in Table 1. The standing horizontal jump was revealed to be a reliable test regardless of the reliability statistic (ICC or CV%) employed or the number of tests used to assess the athletes performance. The ICC's of 0.93-0.99 and CV%'s of 3.81-3.98 indicated strong reliability. Whereas the reliability of the reactive horizontal jump kinetics was less conclusive possibly due to the novelty of the task. Across five trials the peak vertical force (BW) had an ICC of 0.39 indicating that the measure is not reliable, whereas the CV% of 5.86 indicated good reliability. Measures from this test that had conclusive reliability were the peak horizontal force, contact time, and jump displacement. The remaining inconclusive measure was the resultant take-off force. Across all measures the reliability statistics of ICC (3 trials - 0.89, 5 trials - 0.84) and CV% (3 trials – 4.28, 5 trials – 4.37) was marginally stronger when taken from a total of three trials, as opposed to five trials. Linear regression analysis indicated that no significant difference in the measure resulted whether taken from three or five trials. However, the reactive horizontal jump performance appeared better when assessed across five trials (e.g. vertical force: 3 trials – 3.32 $\pm$ 0.40 BW, 5 trials – 3.41 $\pm$ 0.27 BW).

Table 1. Kinetic and kinematic measures of horizontal jumping performance from the first three trials and across all five trials. Linear regression analysis was used to compare the test results from three versus five trials. All linear relationships were statistically valid (p<0.05). VF, HF, and RF denotes the vertical, horizontal, and resultant peak forces, whilst CT abbreviates contact time.

Statistic	Trials (n)	Standing Horizontal Jump				Reactive Horizontal Jump from 45cm Drop				
		VF (BW)	HF (BW)	RF (BW)	Displacement (m)	VF (BW)	HF (BW)	RF (BW)	CT (s)	Displacement (m)
Mean	3	2.11	1.07	2.36	2.16	3.32	0.96	3.40	0.41	2.01
	5	2.10	1.07	2.35	2.16	3.41	1.01	3.50	0.41	2.05
SD	3	0.20	0.15	0.19	0.16	0.40	0.16	0.42	0.09	0.20
	5	0.21	0.14	0.19	0.16	0.27	0.13	0.29	0.08	0.20
ICC	3	0.95	0.98	0.95	0.93	0.64	0.96	0.68	0.95	0.96
	5	0.98	0.99	0.98	0.97	0.39	0.88	0.43	0.95	0.97
CV%	3	3.97	3.81	3.98	3.95	5.54	3.90	5.58	3.82	3.95
	5	3.96	3.83	3.96	3.90	5.86	4.07	5.98	3.83	3.96
r^2	3-5	1.00	0.99	1.00	1.00	0.58	0.88	0.60	0.96	0.98
SEE %	3-5	0.48	1.64	0.50	0.37	8.39	6.28	8.61	5.07	1.45

The validity of the horizontal jump tests from an average of three trials was tested against 10 m sprinting performance. The take-off kinetics measured during the standing horizontal jump was revealed to be a valid predictor of 10 m sprinting performance (best and average) as shown in Table 2. The vertical and horizontal forces measures, when combined, provided an almost perfect (r^2 = 1.00) prediction of the athletes best 10 m sprint time with a negligible standard error of the estimate of 0.25%.

Table 2. The linear regression models of 10 m sprinting performance. SHJ denotes standing horizontal jump and VF and HF abbreviates peak vertical and horizontal forces respectively.

Dependent Measure	Formula	r^2	SEE %
Best 10 m Sprint Time (s)	0.261886 x SHJ_VF - 0.63475 x SHJ_HF + 2.097108	1.00	0.25
Average 10 m Sprint Time (s)	0.294713 x SHJ_VF - 0.69392 x SHJ_HF + 2.116629	0.98	1.03

CONCLUSION: The utility of closed kinetic chain field tests in sports science practice depends on their reliability and validity for the athletic task. Highly sensitive jump kinetic tests are characterized by little variation (technological or biological movement) in consecutive measures of performance. The advantages of reliable and valid tests are that any change in the athlete's performance across consecutive trials can be confidently attributed to their recent training history, and not random fluctuations. The reliability of physical performance in sports science tests has been shown to increase after one trial (Schabort et al. 1999), but can also decline with fatigue. The standing explosive HJ test from three trials was revealed to be valid and reliable in female junior sprinters. The take-off kinetic measures of the normalized horizontal and vertical forces were superior to the traditional field measure of jump distance. Future research should examine the validity of the standing horizontal jump kinetic measures when compared to previously reported vertical jump kinetic tests (e.g. countermovement jump, continuous straight legged jump series) of 10 m sprinting performance in larger cohorts from athletic populations.

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