RELIABILITY ASSESSMENT OF KINEMATIC VARIABLES IN THE MOTION ANALYSIS OF FEMALE SPRINT HURDLES

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INTRODUCTION: There are several studies in the biomechanical literature to test variability and reliability of dynamic movements involving test machines and human performance. However, very little attention has been paid to the reliability of motion analysis in sport applications. Hay (1988) studied reliability as part of the larger examination of the long jump. Recently, Yu and Hay (1995) carried out test and retest reliability studies in the triple jump. By the definition of the statistical test, those studies were carried out by digitizing some trials twice. Thus, the aim of this study was to use several separate trials to study the reliability and to investigate the reliability of kinematic variables in practical applied sports research utilizing sprint hurdles.

METHODS: Eight sprint hurdle clearances each from four national level female athletes were videotaped and digitized. The mean ± SD age, height and mass for the athlete group was 20.1 ± 2.1 years, 1.76 ± 0.04 m and 62 ± 6 kg, respectively. The personal best time ranged from 13.65 s to 14.15 s. The three-dimensional camera and measurement set-up follows the procedure reported by Salo et al. (1997). Following the calculation of 28 kinematic variables, the reliability (R) of the mean of eight trials was determined by using the ANOVA method:

$R = (MS_b - MS_{w+e}) / MS_b$ (Vincent, 1995),

where MS_b is the mean square value between the subjects and MS_{w+e} is the mean square value of within the subject plus error of measurement. The reliability of a certain number of measurements can be estimated from the equation:

$R = (MS_b - MS_{w+e}) / [MS_b + (K / K' - 1) (MS_{w+e})]$ (Baumgartner, 1989),

where additionally K is the number of the original repeated measures, thus eight in this study and K' is the number of repeated measures for which R is estimated; K' = 4, K' = 2 and K' = 1 were used in this study.

RESULTS: Measured reliability of the mean of eight trials and calculated reliability for different K' (K' = 4, K' = 2 and K' = 1) are presented in table 1. The reliability values across the eight trials in 28 variables ranged from 0.54 to 1.00. The highest reliability occurred in the variables of maximum knee angle of lead leg and lead foot lateral movement. The variable with the lowest reliability was the time for maximal angular velocity of the lead leg. The range of the reliability of a single trial (K' = 1) changed to 0.13-0.97. The number of variables to gain different reliability categories when estimated from a different number of measurements are presented in table 2.

Table 1. Measured reliability of the mean of eight trials and calculated reliability for K' = 4, K' = 2 and K' = 1.

	R(8)	R(4)	(R2)	R(1)
TAKE-OFF				
Distance	0.98	0.96	0.92	0.85
Deviation angle	0.92	0.85	0.75	0.59
Take-off angle	0.97	0.93	0.88	0.78
Vertical velocity	0.95	0.91	0.83	0.71
Horizontal velocity	0.97	0.95	0.91	0.83
Trail leg knee angle	0.98	0.95	0.91	0.84
Lead leg minimum knee angle	0.99	0.99	0.98	0.96
Height of CM	0.94	0.89	0.81	0.68
CLEARANCE				
Max. height of CM	0.97	0.95	0.90	0.82
CM distance at maximum height	0.97	0.95	0.90	0.82
CM clearance height	0.96	0.93	0.87	0.77
Minimum hip angle of lead leg	0.99	0.99	0.97	0.95
Maximum knee angle of lead leg	1.00	0.99	0.99	0.97
Maximum angular velocity of trail hip	0.98	0.96	0.92	0.85
Time of max. angular vel. of trail hip	0.97	0.94	0.89	0.80
Maximum angular velocity of lead hip	0.96	0.91	0.84	0.73
Time of max. angular vel. of lead hip	0.54	0.37	0.23	0.13
LANDING				
Distance	0.97	0.95	0.90	0.81
Deviation angle	0.72	0.56	0.39	0.24
Lead leg knee angle	0.87	0.78	0.63	0.46
Lead hip angular velocity	0.95	0.91	0.83	0.71
Vertical velocity	0.94	0.89	0.80	0.67
Horizontal velocity	0.96	0.91	0.84	0.73
Height of CM	0.98	0.95	0.91	0.84
GENERAL				
Stride length	0.95	0.91	0.83	0.71
CM mean horizontal velocity	0.97	0.94	0.89	0.79
Horizontal velocity lost	0.89	0.80	0.67	0.50
Lead foot lateral movement	1.00	0.99	0.98	0.96

Table 2. The number of variables to gain different reliability categories when estimated from a different number of measurements.

R (category)	R(8)	R(4)	R(2)	R(1)
≥0.90	24	21	10	4
0.80≤R<0.90	2	4	13	8
<0.80	2	3	5	16

DISCUSSION: The importance of reliability in biomechanical measurements, although in the context of isokinetic dynamometry, has been addressed by Gleeson and Mercer (1996). However, one problem of reliability studies is, that there are no absolute categories or significance test for reliability. Vincent (1995) created some classification for physiological data. This, however, is not fully applicable for biomechanical data. Nevertheless, the variables over 0.90 level in this study could be considered as highly reliable.

The reliability naturally decreases when less trials are analyzed. In this study, most of the variables (21 of 28), however, gained over 0.90 reliability level when four trials were used for the estimation. The substantial drop in a number of variables to reach this high level appeared, when the reliability estimation was calculated for two trials. Furthermore, the estimated R(1) showed that a single trial is not particularly representative for the kinematic analysis of sport events such as sprint hurdles. Athletes were not able to repeat all the specifics of the demanding skill in every trial. Furthermore, Salo et al. (1996 A and B) indicated the problems in the digitizing process itself.

Although motion analysis can be regarded as an objective method, the manual digitizing involves a subjective evaluation. In a study by Salo et al. (1996A), the operator was not able to exactly repeat the digitization in all parts of the hurdle clearances. The lack of precision occurred mainly in evaluation of those joint landmarks, which were hidden by the other part of the body from the camera view. Initially, each digitized point should be visible for the cameras all the time. If the point is obstructed, the operator (using manual digitization) is required to subjectively evaluate the joint landmark, which eventually results in a digitizing error. However, the effect of such an error on a variable level depended upon, whether the obstruction occurred on the critical part of the performance (Salo et al. 1996B).

Due to the mathematical equation the reliability value can be degraded by increased variation within the subjects or decreased variation between the subjects. The latter means that homogenous performance at a group level may bias reliability values. Closer examination of the results showed that this may have been the case in two variables: the time of maximal angular velocity of the lead leg hip and the deviation angle at landing. These variables yielded the reliability values of 0.37 and 0.56, respectively, when the estimation was based on four trials.

CONCLUSIONS: There were some differences in reliability between kinematic variables studied in sprint hurdles. From practical point of view and in relation to a scientific service to athletes and coaches, a single analyzed trial does not fully disclose the technique. Thus, it is recommended that several trials are analyzed to reveal proper technical representation of athletes performance. Generally, for most of the variables investigated in this study, it seems that four trials would yield reliable results in such events as sprint hurdles.

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