VALIDATION OF AN ELECTRONIC JUMP MAT

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The purpose of this investigation was to determine the validity of a commonly used Electronic Switch Mat (ESM), or jump mat, compared to force platform data. 10 subjects completed 3 Squat Jumps (SJ), 3 Countermovement (CMJ) jumps and 3 Drop Jumps (DJ) from a height of 30cm. The jumps were performed on a force platform (FP) with an ESM positioned on top of the platform. CMJ (r=0.996) and SJ (r=0.958) jump heights correlated very strongly with force platform data however drop jump data was not as strong (r=0.683). The ESM can accurately calculate CMJ height, and SJ height. However, the faster contact times, and rapid movements involved in a DJ may limit its reliability when giving measures of contact time, flight time, and height jumped for DJs.

KEYWORDS: force platform, jump mat, validation.

INTRODUCTION: Several methods of measurement exist for the vertical jump and its performance components, and numerous pieces of equipment are available to the biomechanist and strength and conditioning coach to obtain a measure of lower body power from their athletes. Klavora (2000) highlighted several field tests that are commonly used in research and training contexts and describes the methodology and relative advantages and disadvantages of using each test. The tests that are described include the jump and reach test, belt tests, and electronic switch mat (ESM) tests. Many coaches use ESM's to measure height jumped by their athletes due to the cost effectiveness and portability of such a device (Klavora, 2000; Flanagan & Comyns, 2008). However, the validity of the ESM has not been ascertained and widely published in relation to fixed force platform data. The purpose of this study was to determine the validity and reliability of a commonly used electronic jump mat against a ground mounted force platform for the purpose of measuring various parameters during three types of jump.

METHOD: 10 subjects were recruited (23.6 ± 2.2 yrs, height 174.11 ± 16.63 cm, mass 77.37 ± 16.63 kg) who were all familiar with the three types of jump performed: Squat jump (SJ), Countermovement jump (CMJ) and Drop jump (DJ). The subject base included three track & field athletes, two gaelic hurling players, two Olympic weightlifters, two recreational runners and one rugby union player. Subjects completed three squat jumps, three countermovement jumps and three drop jumps from a height of 30 cm. The jumps were performed on an AMTI OR6-5 force platform operating at 1000 Hz. The jump mat was positioned on top of the force platform and the platform reset. Measured parameters during this study included Flight Time (FT) and Height Jumped (HJ) for both the CMJ and SJ. For the DJ, Contact Time (CT) and Reactive Strength Index (RSI) were also measured in addition to FT and HJ.

For the purpose of the current study an electronic switch mat was used (FLS JumpMat, Tyrone, Ireland). The ESM instrument includes a square mat attached to a hand-held monitor (Figure 1). With the aid of micro switches embedded in the mat, flight time was measured as the interval between feet lift-off from the mat to landing again on the mat.

Subjects warmed-up as they normally would before vigorous activity which included 5 minutes gentle jogging followed by 20 minutes of dynamic progressive ballistic exercises, hops, bounds and jumps. Subjects were permitted 180 seconds between repeats of the same type of jump, and 300 seconds between sets of different jump types to avoid fatigue. Subjects wore shorts, t-shirt and comfortable running shoes. The order of jump type was randomly assigned. Data were tabulated from the AMTI force platform software 'Bioware' and recorded from the ESM output box (Figure 1) and were used to calculate common jump parameters as shown in Table 1.

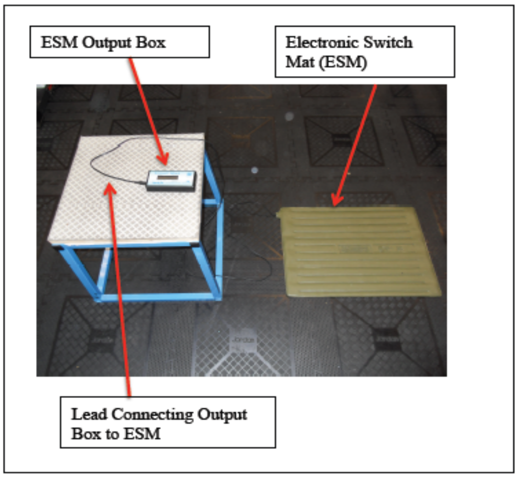

Figure 1. Electronic switch mat positioned over a force platform.

Table 1. ESM and force platform measures and calculations.

Measure	Description
Flight Time (FT)	Time between take-off and landing.
Contact Time (CT)	Time between the initial landing following a drop and the subsequent take-off point.
Height Jumped (HJ)	Calculated from the FT for each jump using the second mathematical equation of linear motion. $\boldsymbol{s = ut + \frac{1}{2}at^2}$ s = displacement u = initial velocity = 0 ms^{-1} t = time to top of jump a = acceleration due to gravity
Reactive Strength Index (RSI)	**RSI = HJ / CT** HJ = Height Jumped CT = Contact Time
Take-off Velocity (V)	**V = √2GHJ** G= acceleration due to gravity HJ = Height Jumped
Power (P)	**P = Vm** V= Take off velocity m = Mass of Subject
Time to Peak Ground Reaction Force (TPGRF)	Time taken for the subject to reach their maximum.

Correlation coefficients were used to identify the strength and directionality of the relationships between the various parameters taken by the force platform and ESM apparatus.

RESULTS: Table 1 highlights descriptive statistics for all parameters as measured by the ESM and the ground mounted force platform.

Table 1. Descriptive statistics for all parameters measured by the ESM and force platform.

	CMJ Height (cm)	CMJ Flight Time (sec)	SJ Height (cm)	SJ Flight Time (sec)	DJ Height (cm)	DJ Contact Time (sec)	DJ Flight Time (sec)	DJ RSI (no units)
ESM Max	0.50	0.64	0.51	0.65	0.34	0.92	0.53	2.45
ESM Min	0.20	0.40	0.17	0.37	0.14	0.14	0.33	0.64
ESM Average	0.32	0.51	0.31	0.49	0.22	0.24	0.42	1.12
ESM St Dev	0.09	0.07	0.09	0.08	0.05	0.15	0.05	0.49
FP Max	0.49	0.64	0.50	0.64	0.34	0.82	0.53	2.52
FP Min	0.19	0.39	0.16	0.36	0.13	0.12	0.32	0.42
FP Average	0.31	0.50	0.29	0.48	0.21	0.25	0.41	0.98
FP St Dev	0.09	0.07	0.09	0.08	0.06	0.13	0.06	0.47

In addition, Table 2 shows the Pearson's correlations between all parameters measured by the EMS and the force platform. All correlations were significant ($p>0.05$) and very strong, except for the DJ Contact Times, and DJ Flight Times.

Table 2. Pearson's correlation coefficients and RMSD for all parameters measured by the ESM and force platform.

	CMJ Height (FP)	CMJ Flight Time (FP)	SJ Height (FP)	SJ Flight Time (FP)	DJ Height (FP)	DJ Contact Time (FP)	DJ Flight Time (FP)	DJ RSI (FP)
Pearson's r	0.996	0.996	0.958	0.946	0.683	-0.173	0.269	0.938
RMSD	2.040	0.000	8.240	0.001	0.000	0.02	0.01	0.040
	CMJ Height (ESM)	CMJ Flight Time (ESM)	SJ Height (ESM)	SJ Flight Time (ESM)	DJ Height (ESM)	DJ Contact Time (ESM)	DJ Flight Time (ESM)	DJ RSI 2 (ESM)

Figure 2 illustrates the strength of the relationships for the key measure height jumped and Table 3 shows for this measure the magnitude by which ESM data is greater.

Table 3. Force platform jump height values as a percentage of ESM data.

	CMJ Height (%)	SJ Height (%)	DJ Height (%)
ESM	100	100	100
FP	96.23	98.04	97.96
% difference	3.77	1.96	2.04

DISCUSSION: Results comparing the two instruments showed very strong correlations for SJ height (0.985), SJ flight time (0.946), CMJ height (0.996), and CMJ flight time (0.996). Although the correlation between the two DJ heights were strong and significant (0.683), the correlations between contact time and flight time in the DJ was very weak (-0.173, and 0.269 respectively). Therefore, the ESM tested in this study is a valid instrument for measurements of height jumped and flight time in CMJ and SJ, but will not produce accurate results when measuring DJs. A possible explanation for the low correlations found for contact time and flight time in the DJs is that the DJ involves a much smaller ground contact period that the relatively inexpensive ESM cannot accurately detect. All data were in line with that reported by Bobbert *et al.* (1996). The use of RSI as a measure of feedback to the athlete and coach for DJ training is relatively new but has been shown here to be ascertained reliably via a jump mat (r=0.938).

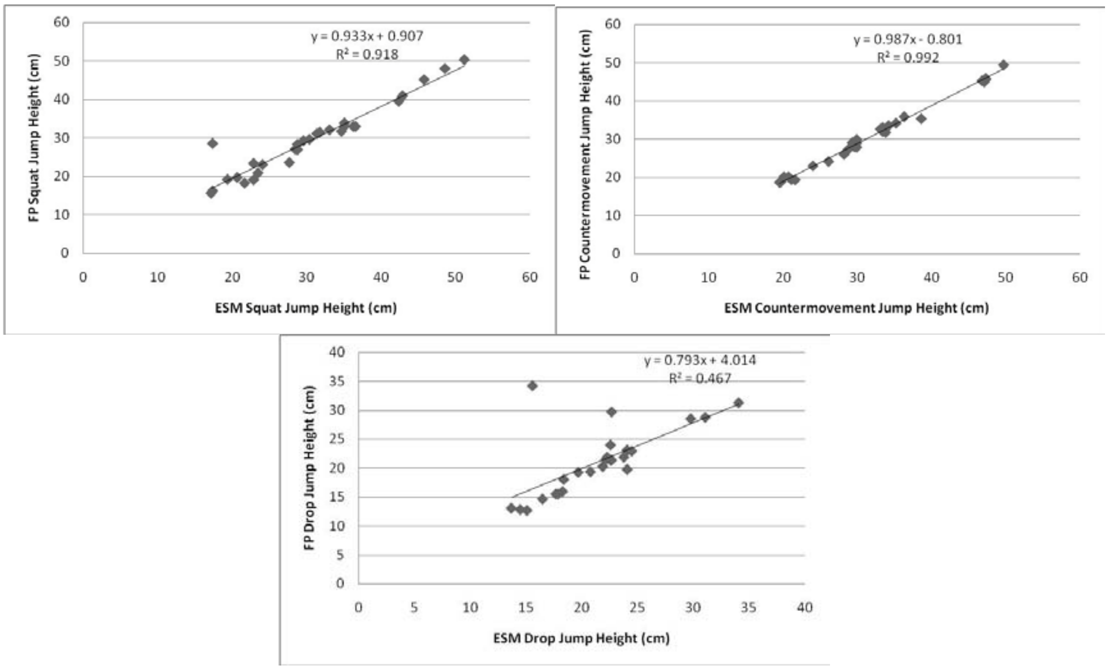

Figure 2. Regression analysis for ESM and force platform height jumped.

CONCLUSION:

- The jump mat consistently yielded data higher in magnitude than the force platform. 1.96%- 3.77% of a difference between FP and ESM readings for CMJ, SJ, and DJ results.
- Correlations between CMJ and SJ on the FP and ESM were all significantly correlated to a high degree (0.996, $p>0.05$).
- DJ data were also significantly correlated (0.683, $p<0.05$) although the correlations were weaker than observed in the CMJ and SJ.

The commonly used jump mat (FLS JumpMat) tested in the current study gave reliable results of vertical jump tests when compared against a ground mounted strain gauge force platform (AMTI OR6-5). This has implications for the strength and conditioning coach in that they can confidently test their athletes in the field, thus avoiding bringing the athletes to the laboratory when relatively simple measures such as height jumped, RSI, and contact time are required. The jump mat may also be a useful resource for researchers carrying out large scale investigations with high subject numbers because the ESM will save time in information processing and experimental set-up. However the ESM is not without its limitations, such as the reduced amount of data produced and errors associated with DJ protocols.

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