



University of  
**Salford**  
MANCHESTER

# A correction equation for jump height measured using the just jump system

McMahon, JJ, Jones, P and Comfort, P

<http://dx.doi.org/10.1123/ijsp.2015-0194>

<b>Title</b>	A correction equation for jump height measured using the just jump system
<b>Authors</b>	McMahon, JJ, Jones, P and Comfort, P
<b>Type</b>	Article
<b>URL</b>	This version is available at: <a href="http://usir.salford.ac.uk/id/eprint/38961/">http://usir.salford.ac.uk/id/eprint/38961/</a>
<b>Published Date</b>	2016

USIR is a digital collection of the research output of the University of Salford. Where copyright permits, full text material held in the repository is made freely available online and can be read, downloaded and copied for non-commercial private study or research purposes. Please check the manuscript for any further copyright restrictions.

For more information, including our policy and submission procedure, please contact the Repository Team at: [usir@salford.ac.uk](mailto:usir@salford.ac.uk).



## A Correction Equation for Jump Height Measured Using the Just Jump System

Journal:	<i>International Journal of Sports Physiology and Performance</i>
Manuscript ID:	IJSPP.2015-0194.R2
Manuscript Type:	Brief Report
Keywords:	biomechanics, physical performance

SCHOLARONE™  
Manuscripts

Peer Review

1 **A Correction Equation for Jump Height Measured Using the Just**  
2 **Jump System**

3

4

5 **Submission Type:** Brief Report

6

7

8 **Authors:** John J. McMahon, Paul A. Jones and Paul Comfort

9

10

11 **Affiliations:** McMahon, Jones and Comfort are with the Directorate of Sport, Exercise and  
12 Physiotherapy, University of Salford, Salford, UK

13

14

15 **Corresponding Author:** Address author correspondence to John J. McMahon at  
16 [j.j.mcmahon@salford.ac.uk](mailto:j.j.mcmahon@salford.ac.uk)

17

18

19 **Preferred Running Head:** Just Jump System: A Correction Equation

20

21

22 **Abstract Word Count:** 250

23

24

25 **Text-Only Word Count:** 1639

26

27

28 **Number of Tables:** 0

29

30

31 **Number of Figures:** 1

32

33

34 **Abstract**

35

36 **Purpose:** The purpose of this study was to determine the concurrent validity and reliability of  
37 the popular Just Jump system (JJS) for determining jump height and, if necessary, provide a  
38 correction equation for future reference.

39

40 **Methods:** Eighteen male collegiate athletes performed three bilateral countermovement  
41 jumps (CMJs) on two JJSs ('alternative method') which were placed on top of a force  
42 platform ('criterion method'). Two JJSs were used to establish consistency between systems.  
43 Jump height was calculated from flight time obtained from the JJS and force platform,  
44 respectively.

45 **Results:** Intra-class correlation coefficients (ICCs) demonstrated excellent within-session  
46 reliability of the CMJ height measurement derived from both the JJS (ICC = 0.96,  $P < 0.001$ )  
47 and force platform (ICC = 0.96,  $P < 0.001$ ). Dependent t-tests revealed that the JJS yielded a  
48 significantly greater CMJ jump height ( $0.46 \pm 0.09$  m vs.  $0.33 \pm 0.08$  m) when compared to  
49 the force platform ( $P < 0.001$ , Cohen's  $d = 1.39$ , power = 1.00). There was, however, an  
50 excellent relationship between CMJ height derived from the JJS and force platform ( $r =$   
51  $0.998$ ,  $P < 0.001$ , power = 1.00) with a coefficient of determination ( $R^2$ ) of 0.995. Therefore,  
52 the following correction equation was produced: criterion jump height = ( $0.8747 \times$  alternative  
53 jump height) – 0.0666.

54

55 **Conclusions:** The JJS provides a reliable, but an overestimated measure of jump height. It is  
56 suggested, therefore, that practitioners who use the JJS as part of future work should apply  
57 the correction equation presented in this study to resultant jump height values.

58

59

60

61

62

63 **Keywords:** Countermovement jump, contact mat, concurrent validity, reliability

64

65

66

67

68

69

70

71

72 **Introduction**

73

74 Vertical jump height provides an indices of lower limb power and as such, vertical jump  
75 testing of various athletic populations is commonplace among sports scientists and coaches.<sup>1</sup>  
76 Many field-based assessments of jump height use contact mats, such as the Just Jump system  
77 (JJS) (Probotics Inc., Huntsville, AL, USA), which estimate jump height from flight time  
78 based on the following equation (1):

79

$$80 \quad JH = \frac{FT^2 \times g}{8} \quad (1)$$

81 *Where JH = jump height, FT = flight time and g = gravitational acceleration (i.e. 9.81 m.s<sup>-2</sup>)*

82

83 The JJS was reported to provide a valid measurement of jump height based on derived results  
84 demonstrating similar values (0.438 ± 0.094 m vs. 0.442 ± 0.103 m,  $p = 0.972$ ) to, and a high  
85 association ( $r = 0.967$ ,  $p < 0.01$ ) with, jump height values derived from a three-camera  
86 motion capture system.<sup>2</sup> Jump height was calculated by quantifying the peak height of a  
87 reflective marker placed on the subjects' sacrum relative to the initial height of the marker  
88 taken whilst subjects were standing as this was purported to be the gold standard method.<sup>2</sup>  
89 The height of the center of mass (COM) at the instant of take-off needs to be taken into  
90 consideration, however, in order for accurate data to be determined via this method. Indeed,  
91 this notion has been addressed in studies which have used a linear position transducer to  
92 calculate vertical barbell displacement by zeroing the take-off height of the barbell whilst  
93 subjects were stood in a fully plantar flexed position.<sup>3</sup> Not accounting for the vertical COM  
94 displacement achieved when subjects plantar flex their ankles would lead to an  
95 overestimation of jump height when using motion analysis and linear position transducers.

96 The JJS has been previously used to explore lower limb power differences between playing  
97 positions (forwards and backs) in elite junior rugby league players<sup>4</sup> and associations between  
98 strength, sprint and jump performance in academy soccer players.<sup>5</sup> As the JJS has been  
99 shown to yield reliable measures of jump height,<sup>6,7</sup> the positional comparisons and  
100 performance associations explored by these researchers are acceptable, but the reported  
101 values may also be used as normative data. Accurate reporting of normative data is essential  
102 for allowing informed decisions regarding the prioritization of training goals to be made.  
103 Force platforms have been used as the criterion measure of jump height (derived from flight  
104 time) in recent studies which have validated the use of both alternative contact mat systems<sup>8</sup>  
105 and iPhone apps<sup>9</sup> alike due to their high sampling frequencies and accuracy in detecting  
106 movement and thus they may provide a more suitable comparison to the JJS.

107 The aim of this study was to determine the concurrent validity and reliability of the JJS for  
108 determining jump height (derived from flight time), with the same calculation applied using a  
109 force platform which acted as a criterion reference. It was hypothesized that there would be a  
110 strong positive relationship between the two jump height measures but that the values derived  
111 from the JJS would be significantly higher than those attained from the force platform.

112

113

## 114 **Methods**

115

## 116 **Subjects**

117 Male collegiate athletes ( $n = 18$ , age  $23.8 \pm 5.0$  years, body mass  $78.7 \pm 10.9$  kg, height  $1.77$   
118  $\pm 0.09$  m) from a variety of sports (e.g. soccer, rugby (both codes) and basketball),  
119 volunteered to participate in this study and provided written informed consent. The study was  
120 approved by the institutional ethics committee and conformed to the principles of the World  
121 Medical Association's Declaration of Helsinki (1983).

122

## 123 **Design**

124 This study employed a within-session repeated measures design whereby subjects attended a  
125 single testing session and performed multiple vertical jumps.

126

## 127 **Methodology**

128 Participants performed six bilateral countermovement jumps (CMJs), interspersed by two  
129 minutes of rest. They were instructed to perform a rapid eccentric phase, to approximately  
130 quarter squat depth, immediately followed a rapid concentric phase with the intention of  
131 jumping as high as possible. A qualified strength and conditioning coach visually ensured  
132 that each participant kept their arms akimbo throughout each jump and avoided flexing their  
133 lower limb joints during the flight phase.

134 Each CMJ was performed on a JJS placed directly on top of a 400-series strain gauge force  
135 platform (Fitness Technology, Adelaide, Australia) sampling at 600 Hz. To ensure any  
136 differences in jump height observed between the JJS and the force platform were not due to a  
137 fault with the contact mat; participants performed the six CMJs on two separate JJSs (i.e.  
138 three jumps per system) in a randomized order.

139 Both flight time and jump height derived from the JJS and the 400-series force platform were  
140 displayed on the attached hand-held computer and on custom software (Ballistic  
141 Measurement System, Fitness Technology, Adelaide, Australia), respectively. Both devices  
142 calculated jump height from flight time using equation 1. For the JJS, flight time was  
143 detected by the micro-switches embedded in the contact mat and for the 400-series force  
144 platform, flight time was determined based on a vertical force threshold of 20 N.

145

## 146 **Statistical Analysis**

147 Relative reliability of CMJ height attained between jump trials was determined using a two-  
148 way random-effects model intra-class correlation coefficient (ICC). The ICC values were  
149 interpreted according to previous work<sup>10</sup> where a value of  $\geq 0.80$  is considered highly  
150 reliable. Absolute reliability of between-trial CMJ height was assessed using the coefficient  
151 of variation (CV). A dependent t-test was used to compare mean differences in CMJ values  
152 derived from the JJS and the force platform. Effect sizes were interpreted using the Cohen  $d$   
153 method which defines 0.2, 0.5, and 0.8 as small, medium, and large, respectively.<sup>11</sup> Pearson  
154 correlation coefficient was used to determine the relationship between CMJ height derived  
155 from the two methods. Dependent t-tests and Pearson correlation coefficients were performed

156 using SPSS software (version 20; SPSS Inc., Chicago, IL, USA). Post-hoc statistical power  
157 was calculated using G\*Power (version 3.1.9.2; University of Dusseldorf, Dusseldorf,  
158 Germany).<sup>12</sup>

159

## 160 **Results**

161

162 Within-session reliability of CMJ height was excellent when assessed using both the JJS and  
163 the force platform, with a comparable ICC value of 0.96 ( $P < 0.001$ ) and CV values of 3.7%  
164 and 4.7%, respectively. CMJ height derived from each JJS was identical to one another ( $0.46$   
165  $\pm 0.09$  m), but significantly greater ( $P < 0.001$ , Cohen's  $d = 1.39$ , power = 1.00) than values  
166 determined using the force platform ( $0.33 \pm 0.08$  m).

167

168

169

170

171 There was a positive relationship between CMJ height derived from the JJS and the force  
172 platform ( $r = 0.998$ ,  $P < 0.001$ , power = 1.00) which resulted in a coefficient of determination  
173 ( $R^2$ ) of 0.995 (Figure 1). Given the near perfect coefficient of determination observed  
174 between the two systems, a linear regression equation was established to allow vertical jump  
175 height values derived from the JJS to be corrected (Figure 1).

176

177

178 INSERT FIGURE 1 ABOUT HERE

179

180

181

## 182 **Discussion**

183

184 This study aimed to determine the concurrent validity of the JJS for determining jump height  
185 (derived from flight time) by comparing it to those calculated using the same method using a  
186 force platform (criterion reference). The main finding of this study was that the JJS  
187 overestimated CMJ height when compared to the force platform ( $0.46 \pm 0.09$  m vs.  $0.33 \pm$   
188  $0.08$  m), in line with the hypothesis; suggesting that the JJS does not provide a valid measure  
189 of jump height. This finding opposes those of an earlier study which validated the JJS against  
190 a three-camera motion capture system.<sup>2</sup> As mentioned earlier, the aforementioned authors  
191 did not account for the effects of plantar flexion demonstrated prior to the take-off phase of  
192 vertical jumping which subsequently led to an overestimation of jump height. The JJS may  
193 have overestimated CMJ height due to the associated hardness of contact mats requiring a  
194 large minimum force (perhaps  $> 20$  N) in order to activate its mechanical circuit and detect  
195 landing.<sup>8</sup>

196

197 Despite the large mean difference in jump height, there was an excellent relationship between  
198 the two systems ( $r = 0.998$ ) with values from the JJS able to explain 99.5% of the variance of  
199 values from the force platform (Figure 1). This is useful in that jump height values  
200 determined using the JJS can be subsequently corrected based on the following equation (2):

201

202

203 
$$CJH = (0.8747 * AJH) - 0.0666 \quad (2)$$

204 *Where CJH = criterion jump height (m) and AJH = alternative jump height (m)*

205

206 In addition to demonstrating a high association with data derived from the force platform,  
207 CMJ height derived from the JJS also yielded identical within-session reliability (ICC =  
208 0.96). This finding is in line with previous work<sup>6,7</sup> and suggests that the JJS can be utilized as  
209 a reliable field-based method of determining jump height. Based on reliability data, it is  
210 viable that the JJS can be used to monitor changes in jump height in future studies, despite  
211 the attained values being inflated in comparison to the criterion measure, by applying  
212 equation 2 to the data.

213

214 When interpreting the results of this study, it should be noted that previous studies found that  
215 the flight time method (equation 1) overestimated CMJ height (by approximately 3% in  
216 males<sup>13</sup>) when compared to the preferred velocity at take-off method.<sup>13,14</sup> This error in jump  
217 height estimation was attributed to postural changes during the flight phase of the jumps (e.g.  
218 tucking the legs)<sup>13</sup>, however, it is important to note that the present study did not include any  
219 CMJ trials that were performed in this manner and thus any associated error may considered  
220 negligible.

221

222

### 223 **Practical Applications**

224

225 It is suggested that practitioners who use the JJS should apply equation 2 to all future data in  
226 order correct their values. Equation 2 can also be applied to previous research which has used  
227 the JJS to calculate jump height. This would bring the jump height values attained in those  
228 studies in line with the criterion reference and thus provide practitioners with the ability to  
229 interpret this data more accurately.

230

231

### 232 **Conclusions**

233

234 The JJS is reliable, but overestimates jump height when compared to the flight time-derived  
235 jump height obtained from the force platform.

236

237

238

### 239 **References**

240

- 241 1. Klavora P. Vertical-jump tests: a critical review. *Strength & Conditioning Journal*.  
242 2000;22(5):70-74.
- 243 2. Leard JS, Cirillo MA, Katsnelson E, et al. Validity of two alternative systems for  
244 measuring vertical jump height. *The Journal of Strength & Conditioning Research*.  
245 2007;21(4):1296-1299.
- 246 3. Thomasson ML, Comfort P. Occurrence of fatigue during sets of static squat jumps  
247 performed at a variety of loads. *The Journal of Strength & Conditioning Research*.  
248 2012;26(3):677-683.
- 249 4. Kirkpatrick J, Comfort P. Strength, power, and speed qualities in english junior elite  
250 rugby league players. *The Journal of Strength & Conditioning Research*.  
251 2013;27(9):2414-2419.



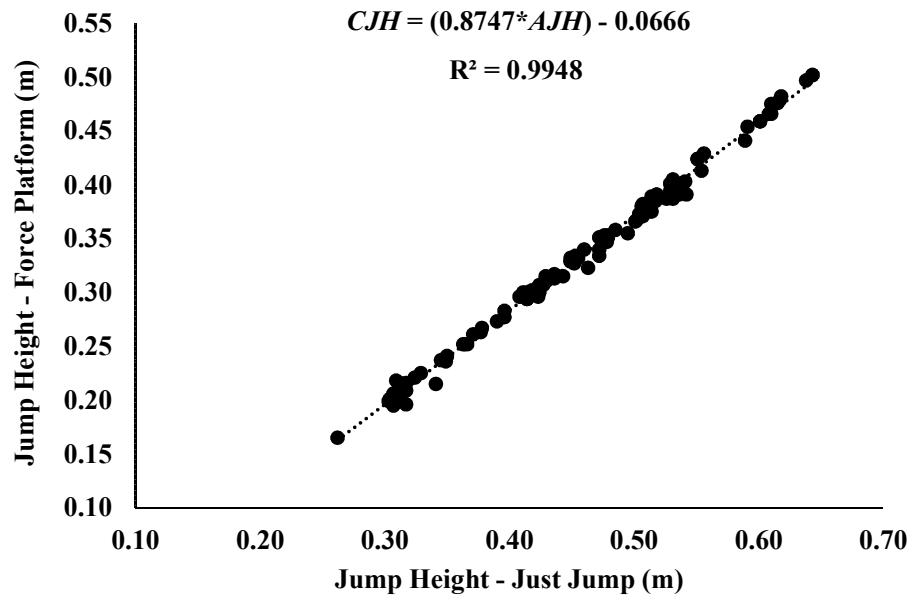
- 252 5. Comfort P, Stewart A, Bloom L, Clarkson B. Relationships between strength, sprint,  
253 and jump performance in well-trained youth soccer players. *The Journal of Strength*  
254 *& Conditioning Research*. 2014;28(1):173-177.
- 255 6. Nuzzo JL, Anning JH, Scharfenberg JM. The reliability of three devices used for  
256 measuring vertical jump height. *The Journal of Strength & Conditioning Research*.  
257 2011;25(9):2580-2590.
- 258 7. Moir G, Shastri P, Connaboy C. Intersession reliability of vertical jump height in  
259 women and men. *The Journal of Strength & Conditioning Research*.  
260 2008;22(6):1779-1784.
- 261 8. García-López J, Morante JC, Ogueta-Alday A, Rodríguez-Marroyo JA. The type of  
262 mat (contact vs. photocell) affects vertical jump height estimated from flight time. *The*  
263 *Journal of Strength & Conditioning Research*. 2013;27(4):1162-1167.
- 264 9. Balsalobre-Fernández C, Glaister M, Lockey RA. The validity and reliability of an  
265 iPhone app for measuring vertical jump performance. *Journal of Sports Sciences*.  
266 2015/03/12 E-Pub:1-6.
- 267 10. Cortina JM. What is coefficient alpha? An examination of theory and applications.  
268 *Journal of Applied Psychology*. 1993;78(1):98-104.
- 269 11. Rhea MR. Determining the magnitude of treatment effects in strength training  
270 research through the use of the effect size. *The Journal of Strength & Conditioning*  
271 *Research*. 2004;18(4):918-920.
- 272 12. Faul F, Erdfelder E, Buchner A, Lang AL. Statistical power analyses using G\*Power  
273 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*.  
274 2009;41(4):1149-1160.
- 275 13. Moir GL. Three Different Methods of Calculating Vertical Jump Height from Force  
276 Platform Data in Men and Women. *Measurement in Physical Education and Exercise*  
277 *Science*. 2008;12(4):207-218.
- 278 14. Aragón LF. Evaluation of Four Vertical Jump Tests: Methodology, Reliability,  
279 Validity, and Accuracy. *Measurement in Physical Education and Exercise Science*.  
280 2000;4(4):215-228.

281

282

283

284 **Figures**



285  
286  
287  
288  
289

Figure 1: Relationship between vertical jump height values derived from the Just Jump system and the force platform for pooled data taken from the six ( $n = 108$ ) jump trials (where CJH = criterion jump height and AJH = alternative jump height).