Validity and reliability of the Danu System for Drop Jumps

Introduction

Plyometrics training has always been an important topic among coaches and researchers. The drop jump (DJ) is a core part of plyometrics training, commonly utilised to both access and train an athletes' stretch-shortening cycle (SSC) ability [1] [2]. Not only can it be used to monitor an athlete's performance [3], but in addition their readiness-to-train [4] and for injury-risk screening [5] [6] [7]. Traditionally, practitioners have employed force plates to assess DJ performance, which are widely regarded as the gold standard [8] [9]. Recently, however, there has been a shift towards more cost-effective and practical alternatives that can be integrated into natural sporting environments, facilitated by advances in wearable technology (Marković et al., 2021). This study aims to investigate the concurrent validity and reliability of the Danu Sports system in measuring Drop Jump flight time, jump height, contact time, and reactive stress index (RSI), comparing its performance against that of a force plate (ForceDecks Dual Force Plate System, VALD Performance PTY LTD, Queensland, Australia).

Method

Thirty-one team sport players (24 males, 7 females) volunteered for this study. Participants were asked to perform three drop jumps (DJs) while wearing Danu socks (figure 1a) and using their own footwear on Vald ForceDecks (figure 1b). For established standards, a 30 cm high platform was used for each DJ trial [8].

All metrics (FT, JH, CT, RSI) were calculated by identifying final contact and initial contact, through custom algorithms developed to process the raw sensor data collected from the Danu socks and highlighted in figure 2. Jump height is derived from flight time [10] as shown in equation 1, and RSI is calculated as a ratio of contact time and flight time [11], as shown in equation 2.

$$\text{Jump height (cm)} = \frac{t^2 \cdot g}{8} \qquad (1)$$

$$RSI = \frac{Flight\ time}{Contact\ time} \quad (2)$$

A total of 89 DJs were recorded with 4 DJs not included due to collection errors. The data analysis included Intraclass Correlation Coefficient, Pearson Correlation Coefficient, Bland-Altman Analysis, Adjusted R^2, Mean Absolute Error (MAE), and Root Mean Square Error (RMSE), selected for their robustness in assessing measurement accuracy and agreement between the Danu system and Vald force plates.

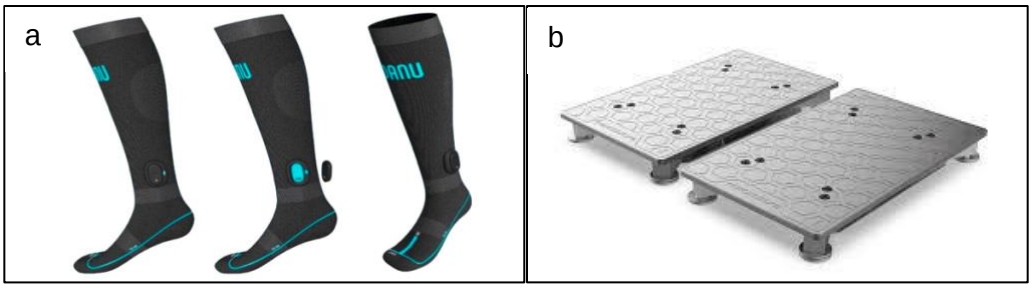

Figure 1. (a) Danu Sports Smart Sock. (b) Vald ForceDecks Force Plates.

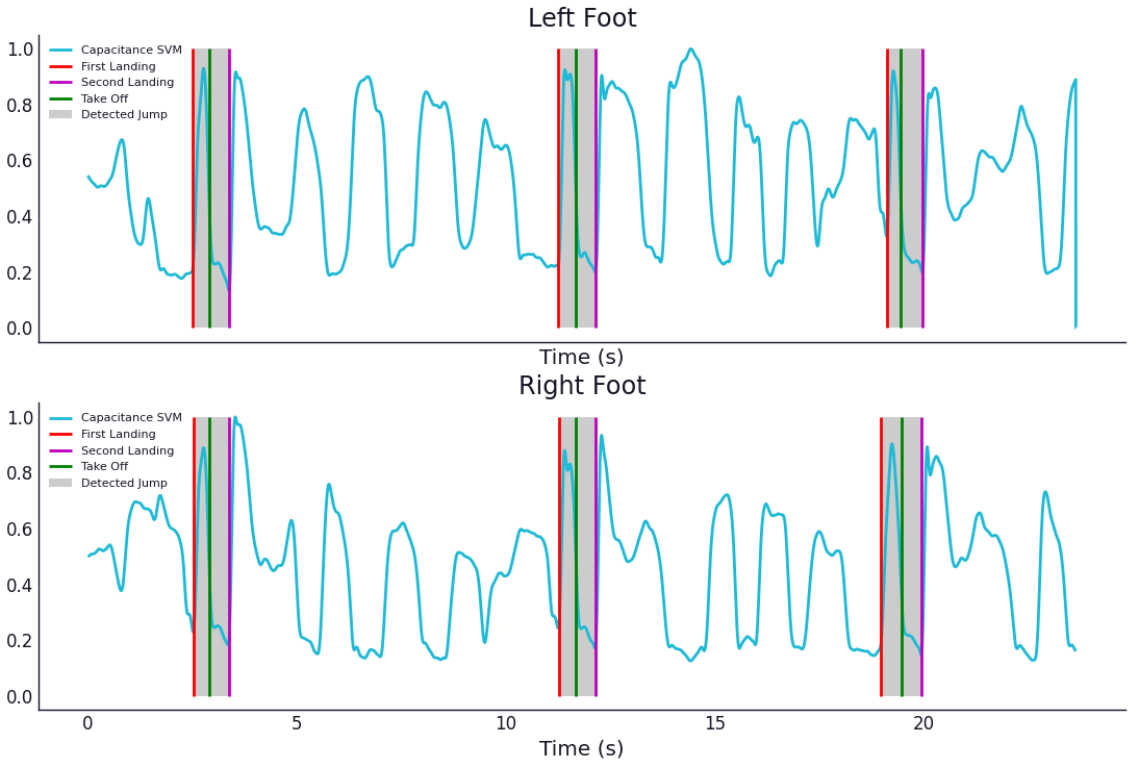

Figure 2. Visualisation of raw sock data and jumps detected.

Results

The Intraclass Correlation Coefficient (ICC) values derived from comparisons between the Danu system and the force plates were consistently > 0.9 (0.95-0.98), indicating an excellent agreement between the two systems [12]. The results highlight the reliability and accuracy of the Danu system in replicating measurements obtained from the force plates with the Bland-Altman analysis mean difference sat at -0.01s for contact time, 0s for flight time, -0.11cm for jump height, and -0.07 for RSI with no significant systematic bias. The Pearson R^2 analysis yielded all values > 0.9 (0.92 – 0.97), indicating a very strong correlation [13].

For a detailed breakdown of the results for each metric along with the statistical analyses conduced, refer to table 1.

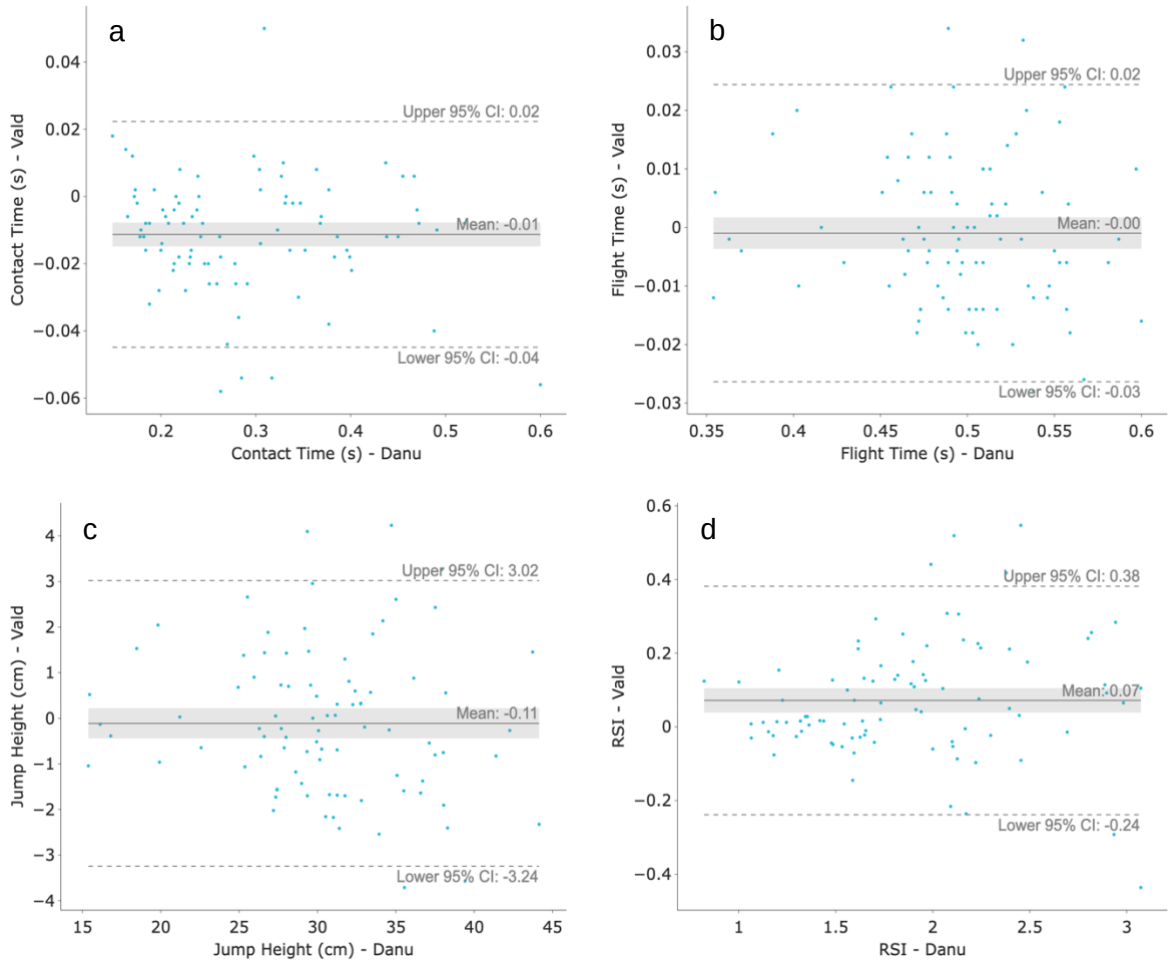

Figure 3. Bland-Altman plot for comparison between Danu and Vald (a) contact time (s), (b) flight time (s), (c) jump height (cm), (d) RSI.

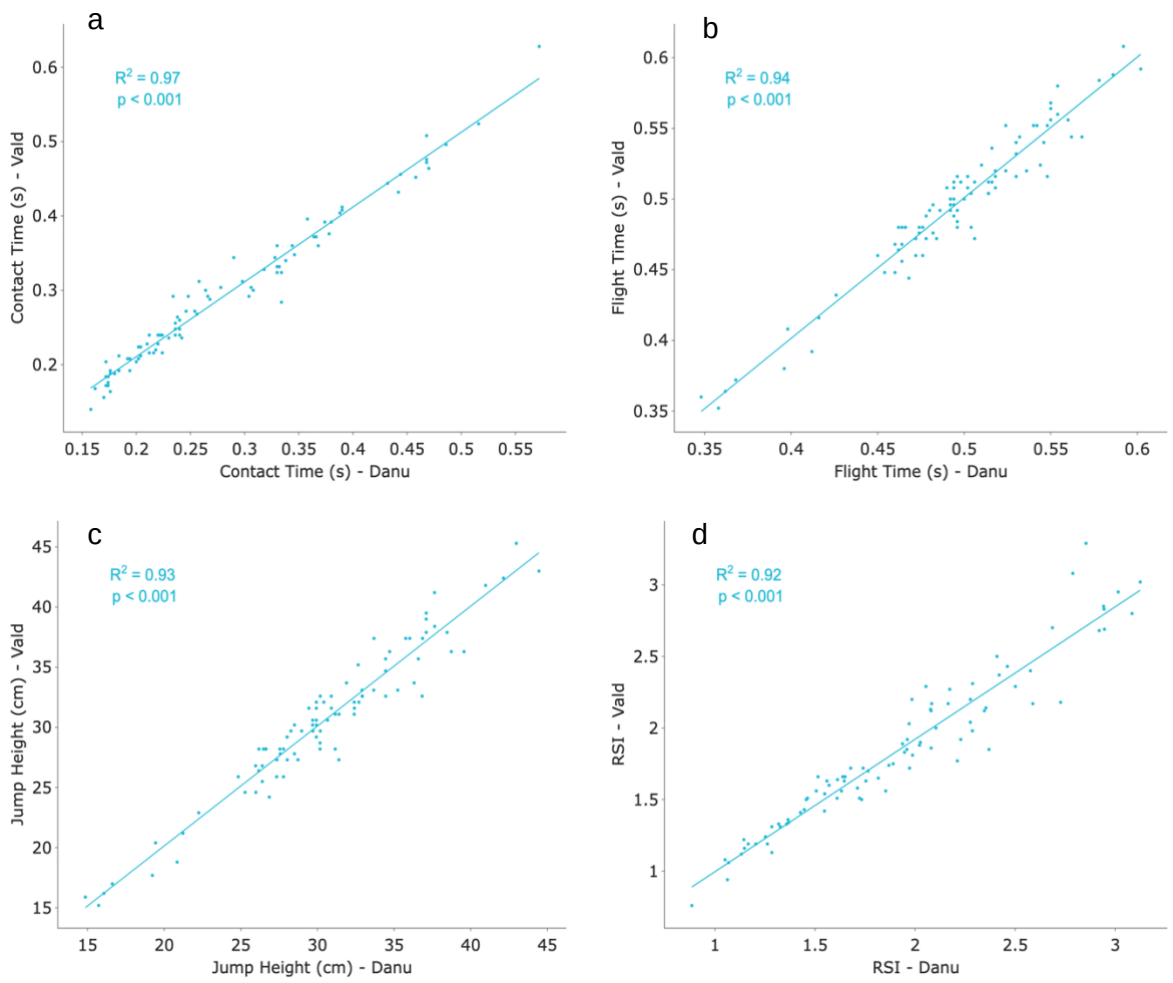

Figure 4. Scatter plot comparison for (a) contact time (s), (b) flight time (s), (c) jump height (cm), (d) RSI.

Table 1. *Statistical analysis outcomes.*

Metric	*MAE*	*ICC*	*Pearson r*	*Adj. R2*	*Pearson p*	*RMSE*	*Bland-Altman (Mean, upper, & lower limits*
Flight Time (s) (n = 114)	0.01	0.97	0.97	094	<0.001	0.013	0.00, +0.02, -0.03
Jump Height (cm) (n=114)	1.28	0.96	0.97	0.93	<0.001	1.60	-0.11, +3.02, -3.24
Contact Time (s) (n =)	0.01	0.98	0.99	0.97	<0.001	0.02	-0.01, +0.02, -0.04

RSI	0.12	0.95	0.96	0.92	<0.001	0.16	-0.07, +0.38, -0.24

Conclusion

This study provides a preliminary analysis of the validity and reliability of the Danu system for deriving metrics for drop jump analysis when compared to the ground truth, force plates (ForceDecks). The strong correlation and excellent agreement between the two systems, paired with a minimal deviation for the upper and lower limit are well within other validity studies for wearable technology [14] [15] and suggests Danu is an excellent option for drop jump analysis.

Furthermore, Danu's ease of use and portability enables comprehensive monitoring of athletic performance in diverse environments, allowing practitioners to perform analysis without the need for designated space and bulky equipment, alleviating the need to transport and setup the equipment. It can also ease the workload on practitioners for analysis, providing instant feedback that can be actioned and tailored for each individual. Future independent studies are encouraged and can help verify these findings.

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