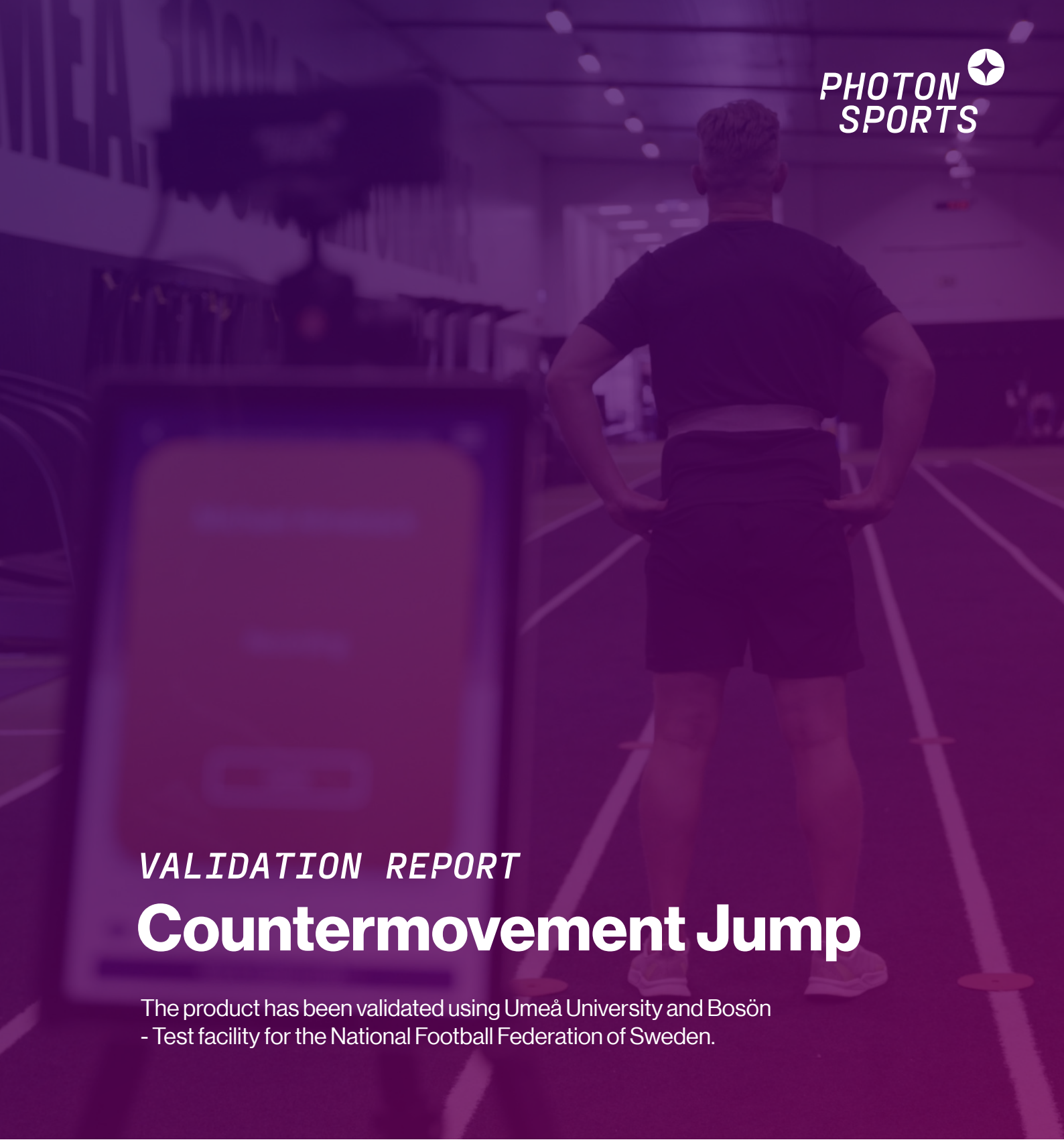


PHOTON SPORTS

VALIDATION REPORT

Countermovement Jump

The product has been validated using Umeå University and Bosön - Test facility for the National Football Federation of Sweden.

2022-05-03

1. Intro

Photon Sports have developed an easy to use measurement system in order to measure and give feedback to athletes during performance tests. The system consists of a 3D camera that captures images with depth information at 60 Hz, and a host computer that processes these images in real time and extracts the 3D positions of an elastic waist belt that an athlete wears during the test. These 3D positions are combined with algorithms to calculate for example jump height. This document is produced internally and data has been collected using research grade motion capture equipment at UMEX, Umeå Movement and EXercise Laborator, at Umeå University.

1.1 Goal

The goal of this document is to present how the Photon Sports measurement results compares to a gold standard measurement equipment for motion capture. Specifically presenting an estimate of the measurement performance for measurements of countermovement jumps (CMJs) with the Photon Sports system.

2. Background

Measuring jump heights of countermovement jumps and squat jumps in the field with high reliability is of interest for several reasons[1][2]. Jumping is for example commonly used as an input for field-based estimates of athlete lower body power. To accurately measure jump height with a portable system in a team setting is of value to athletes and coaches.

2.1 What is measured?

Photon Sports uses a 3D camera and a reflective waist belt in order to measure the 3D position of the reflective belt - more accurately, in the 3D image that is captured, the belt shows up as an object. The centroid - or geometric centre of this blob is what defines the X (side position) and Y (vertical) coordinate of the athlete, while the average depth of this object is what defines the Z coordinate of the athlete.

2.2 Jump height definition

Photon Sports uses the height along the aforementioned Y-axis of the camera for height measurements. Proper alignment of the camera using the built in bubble level aligns this axis with the vertical direction. For a vertical jump such as the CMJ, the jump height is measured as the difference between the peak height along the Y-axis compared to the average height at the reference positions before and after the jump, see figures 1 and 2.

Note that compared to so called flight time methods Photon Sports technology allows for direct measurement of the displacement of the waist, i.e. jump height. This jump height is typically 10-12 cm higher than the flight time calculated “flight height”, see Appendix B.

[1] Harman, E.A., et al., Estimation of Human Power Output from Vertical Jump. The Journal of Strength & Conditioning Research, 1991. 5(3): p. 116-120

[2] Sayers, S.P., et al., Cross-validation of three jump power equations. Medicine & Science in Sports & Exercise, 1999. 31(4): p. 572-577.

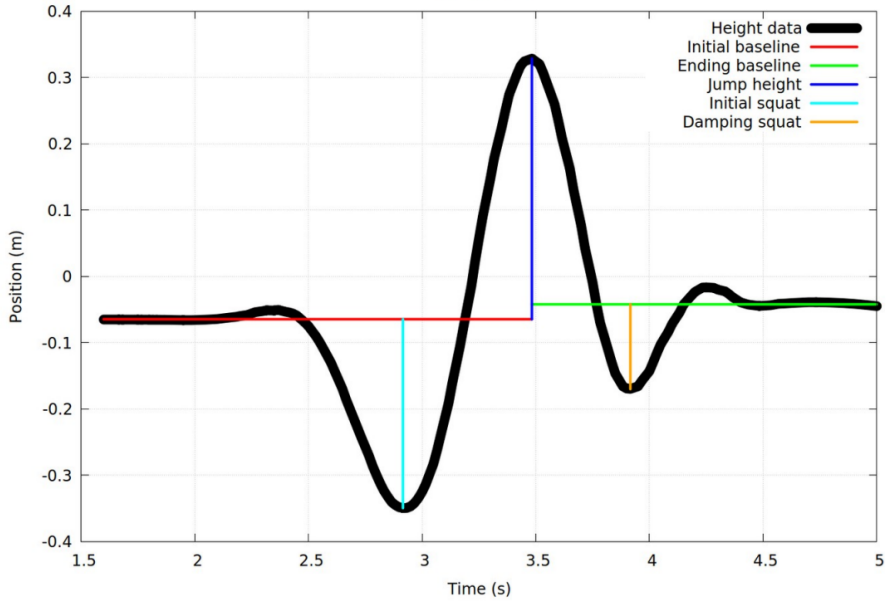


Figure 1: Sample data for a single CMJ where the three measured vertical positions “Initial baseline”=before jump reference position,”max height reached”=maximum position along the Y-axis detected for the jump and “Ending baseline” = after jump reference position, can be seen.

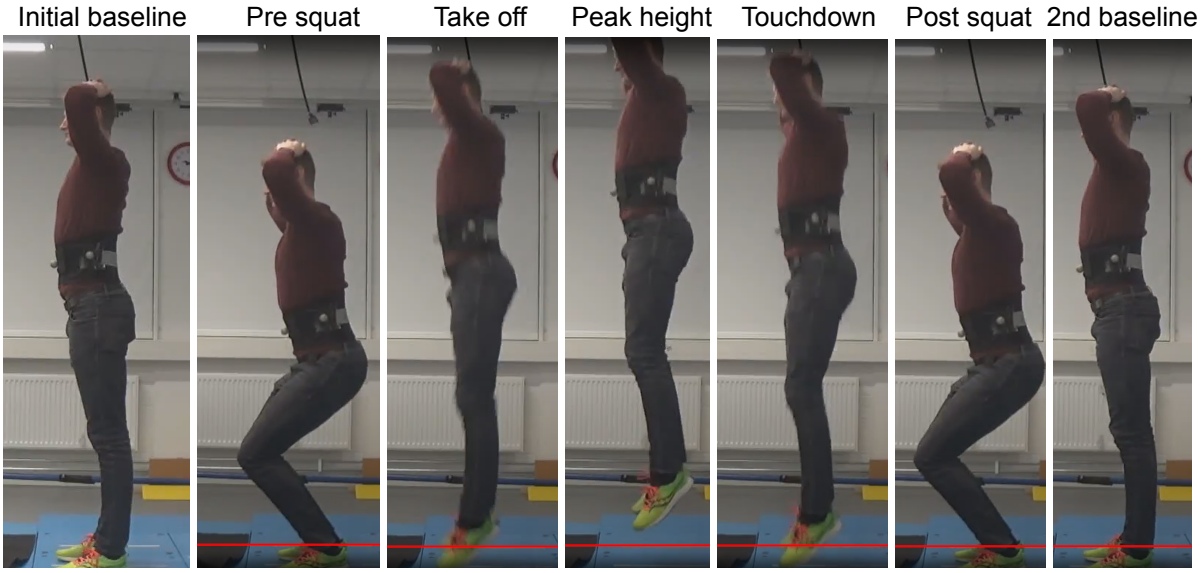


Figure 2: Jump sequence.

3. Test setup

In order to measure how accurate the calculated jump height of the Photon Sports system is, data was collected simultaneously using two systems. A Motion capture system (Qualisys) and Photon Sports. The data were simultaneously collected using Qualisys Track Manager software (Qualisys AB, Göteborg, Sweden) and Photon Sports Capture App respectively. The raw position data from Qualisys of two markers, figure 4, named marker 1 and 2 and the 3D positions from Photon Sports were collected and run through the same algorithms to calculate the two reference positions and the peak position for each jump.



Figure 3: 5 Qualisys cameras were positioned in front of the athlete measuring the position of two markers while the Photon Sports 3D-camera was recording the position of the waist belt on the back of the athlete.

The motion capture (MoCap) system is operating at a 240 Hz sampling frequency and collected data from 2 markers (19 mm diameter reflective spheres) using 5 cameras. The two markers were attached to the left and right side of the hips as shown in figure 4.

The Photon Sports camera was placed about 4 m behind the athlete position at chest height, about 1.5 m.

Note: Oqus and Photon Sports use the same wavelength of light for measuring. Both systems also use reflective markers (spheres and waist belts respectively). This makes it necessary to restrict the MoCap markers to the front of the waist and the waist belt to the back. Hence, not exactly the same movement can be expected due to trunk flexion and tilt.



MoCap Spheres in front of the black view restrictors

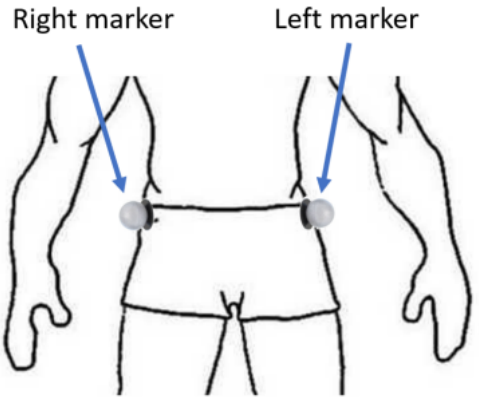


Figure 4: Photon Sports measures the position of the waist belt as viewed from behind the athlete under test. Qualisys was set-up to measure the position of two spheres, markers, positioned as shown above. The two spheres were positioned with an offset to the waist belt since the two systems otherwise interfere with each other.

3.1 Sources of error

1. Difference in movement between Qualisys spheres and waist belt. Any difference in movement between the waist belt and the spheres would decrease the correlation if not systematic. A slight tendency for a more backwards lean could be seen at peak position for higher jumps compared to lower jumps.
2. Levelling of the camera - keeping the camera within 5° gives a misalignment error of less than 0.5%, by trigonometry cos(5°) = 0.996 giving the camera's Y-axis not aligned with the vertical direction. Keeping the bubble within the circle gives about 2° accuracy.
3. Loose hanging clothes - partial obscuration of the waist belt or MoCap markers may lead to unwanted offsets of the measured position.
4. Movement of the waist belt on the body between first reference and last reference
5. Not standing still and upright during the two reference measurements
6. Soft tissue deformation - since the waist belt and MoCap spheres are not mounted on a rigid body, movement of the skin or tissue underlying the waist belt may lead to slight differences in the movement of the waist belt and spheres.
7. Interference between the two systems. It was necessary to restrict the two systems from illuminating the same part of the athlete.

3.2 Qualisys accuracy

In the actual setting with the cameras used, the pre-test calibration of the Qualisys set-up showed an estimated accuracy of ±0.9 mm. Note that this is for the measurement of the 3D position of the spherical targets and not the waist belt.

4. Result

45 CMJs were recorded for two athletes at two different sessions. In the first session seven jumps were recorded and in the second 38 jumps were measured. An example of recorded data can be seen in figure 5.

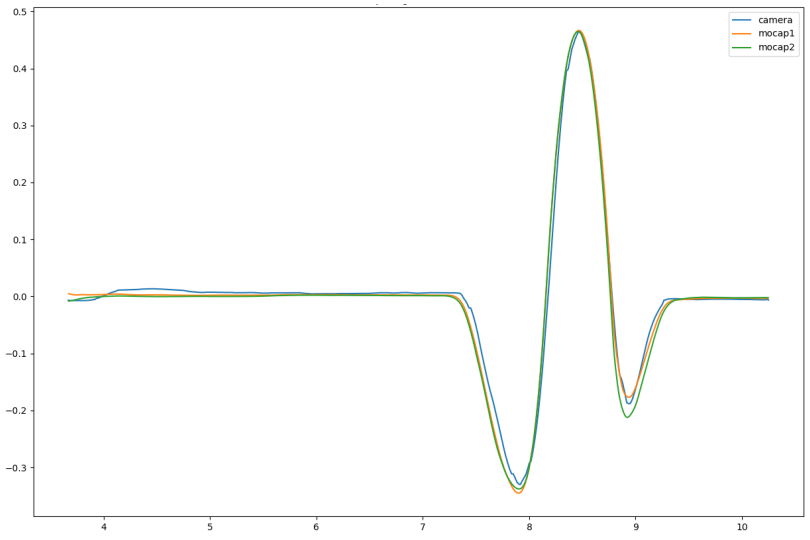


Figure 5: Example of data from a single CMJ.

The recorded jump heights were between 19 and 46 cm, i.e. the athletes jumped with varying amounts of effort. The average jump height measured with Qualisys was 352 mm and with Photon Sports 349 mm.

The difference in jump height between Qualisys and Photon Sports for each individual jump can be seen in figure 6. The standard deviation of these differences was 6.5 mm. Excluding the four jumps with the largest deviation gives 359 and 358 mm and a standard deviation of 4.5 mm.

Figure 6 shows recorded data from session 2, 38 jumps, for both systems.

In figure 7, a Bland-Altman plot of the 38+7 jumps are shown.

Due to previously mentioned limitations in the placing of the two different types of markers it is likely that a part of the disagreement is due to the fact that the waist belt and spherical markers actually moved differently. An indication for this can be seen in Appendix A. In appendix A data was recorded using a “jump machine”. Repeatability, calculated as standard deviation between 12 simulated jumps, was 1-2 mm.

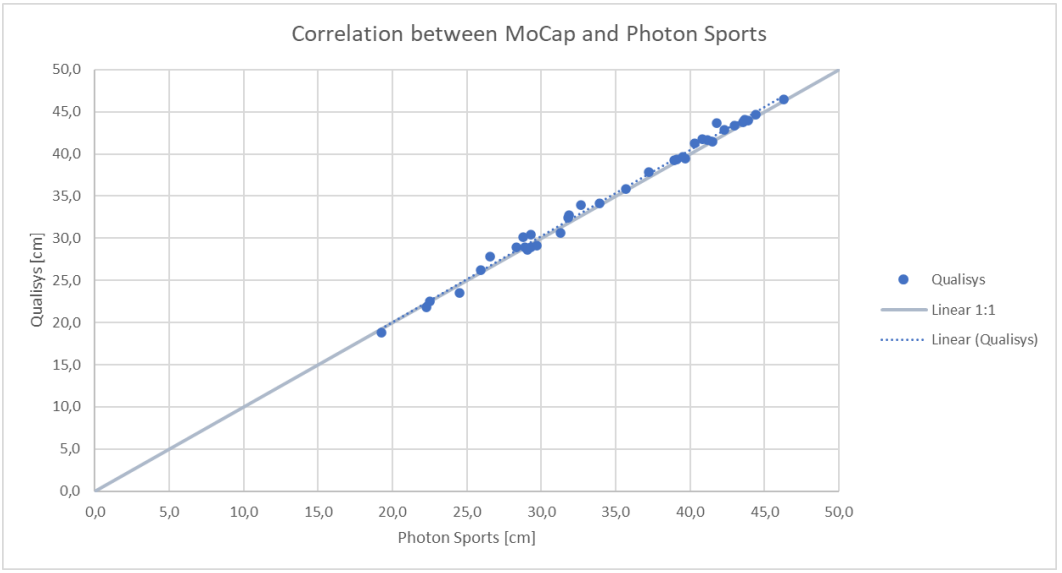


Figure 6: Jump height for Qualisys plotted vs. Photon Sports.

Parameter	Correlation	Formula
r	0,997	CORREL(C3:C51;D3:D51)
R squared = r^2	0,994	r^2
R squared using RSQ	0,994	RSQ(C3:C51;D3:D51)

Table 1: Correlation between Qualisys and Photon Sports for 38 individual jumps.



Figure 7: Bland-Altman plot of the difference between Photon Sports and Qualisys at different jump heights.

Appendix A

Jump machine data

Photon Sports has built a basic “jump machine” that can simulate a jump without the pre and post squat. The machine can be set to perform jumps with different heights and is good at repeating the same jump. Performing repeated simulated jumps shows a repeatability between jumps of about 1-2 mm.

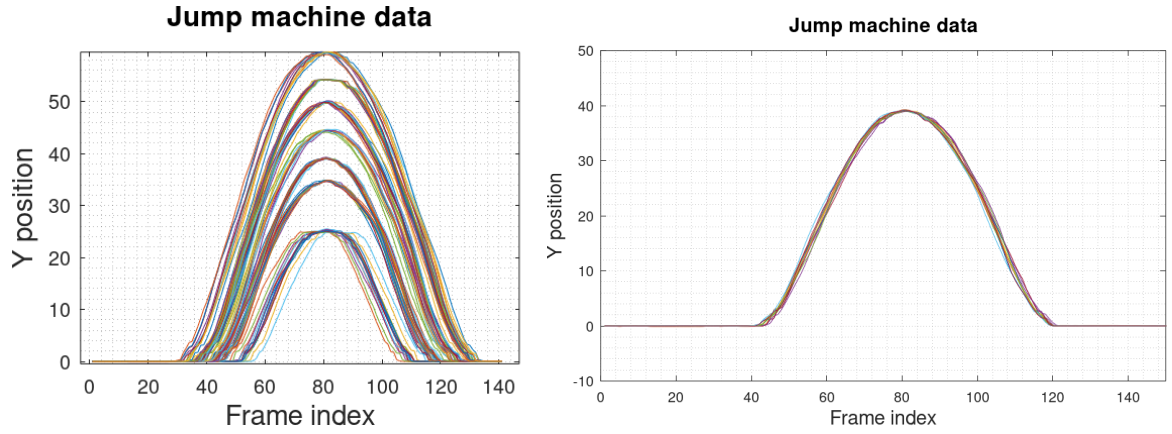


Figure A1: Jump machine data with multiple (12-15) jumps recorded at each height setting (25-60 cm).

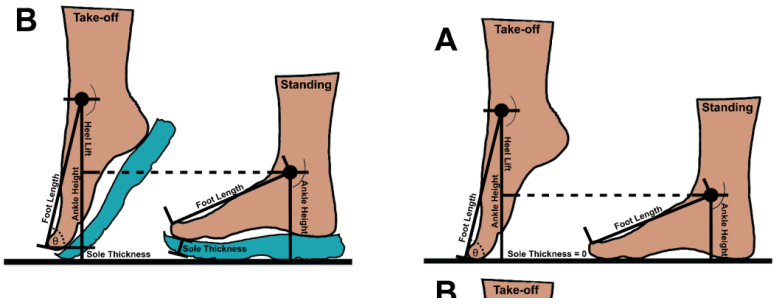
Appendix B

Comparison to flight time methods

Flight-time method calculates, i.e. it does not measure, the distance travelled by the centre of mass (COM) whilst in the air. This estimate only accounts for one component of jump height, i.e. the flight distance and does not include the heel-lift distance caused by ankle rotation prior to take-off.

The flight-time method underestimates jump height by approximately 10-12 cm[3][4] compared to methods that more directly determine jump height[5][6].

Subtract 10-12 cm depending on Foot length, ankle height and Θ. In ref 3 a possible



$$Constant = (0.88 \times \ Foot\ Length) + Sole\ Thickness - Ankle\ Height$$

Figure B1: Figure from ref 4, Flight time vs. marker based jump height difference with and without shoes.

[3] Moir, G.L., Three Different Methods of Calculating Vertical Jump Height from Force Platform Data in Men and Women. Measurement in Physical Education and Exercise Science, 2008. 12(4): p. 207-218.
[4] Comparisons of laboratory-based methods to calculate jump height and improvements to the field-based flight-time method (bath.ac.uk)
[5] Buckthorpe, M., J. Morris, and J.P. Folland, Validity of vertical jump measurement devices. Journal of Sports Sciences, 2012. 30(1): p. 63-69.
[6] Aragón-Vargas, L.F., Evaluation of Four Vertical Jump Tests: Methodology, Reliability, Validity, and Accuracy. Measurement in Physical Education and Exercise Science, 2000. 4(4): p. 215-228.