Comparison between the trajectory and movement velocity of shoulders vs. hip during vertical jumps

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Introduction:
The vertical velocity at takeoff has been extensively used for estimating the height achieved during vertical jumps [1]. Although this criterion has been applied when exercising on a force or a contact platform (1), recent works have calculated the height of the jump by measuring the displacement using a velocity transducer attached to the bar positioned at the shoulders' level (2,3).

Purpose:
The aim of this study was to compare the vertical displacement and velocity of the shoulder and hips during the Countermovement Jump (CMJ) exercise performed with light to moderate overloads.

Materials and methods:
After 1 day of familiarisation, twenty-three men (age 29.3±3.4 years; body mass 75.6±7.6 kg; height 178.7±6.4 cm) completed a progressive jump test on a smith machine, which consisted of 5 sets of 3 repetitions of CMJ with 2 to 3 minutes of rest between sets. The participants jumped against loads of 3.5; 13.5; 23.5; 33.5; and 43.5 kg. These absolute loads represented an equivalent mean resistance of ~5%, 15, 25, 40, 50% of the estimated 1RM in the deep squat. In each set, the repetition that produced the highest propulsive average velocity was selected for the analysis. Two Optoelectronic System devices (Velowin®), placed at both sides of the participants (Figure 1) were used to estimate the displacement and the velocity achieved by the hip (X) and shoulders (Y) during the ascending phase (including both the contact-propulsive and fly time) of the CMJ.

Statistical analysis:
Pearson product-moment correlation was applied to determine associations between the compared variables (displacement, average and peak velocity). Five paired samples t-tests (one per load) were used to determine potential differences between the displacement and velocities measured at shoulder and hip. The level of significance (0.05) was adjusted using Bonferroni's method.

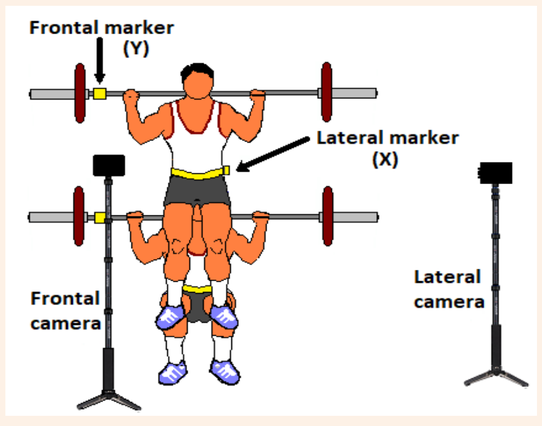

Fig. 1 The Velowin® system using two cameras for measuring the the displacement of the markers placed close to the shoulders and the hip during the CMJ exercise

Results:
Significant ($p<0.001$) shorter displacement (Figure 2) and lower average, and peak velocities (Figures 3 and 4 respectively) were measured at the hip compared to the shoulder position for all the assessed loads.
Significant ($p<0.001$) and strong ($r>0.7$) or very strong ($r>0.80$) Pearson product-moment correlations were observed for the displacement and velocities of all the evaluated loads.

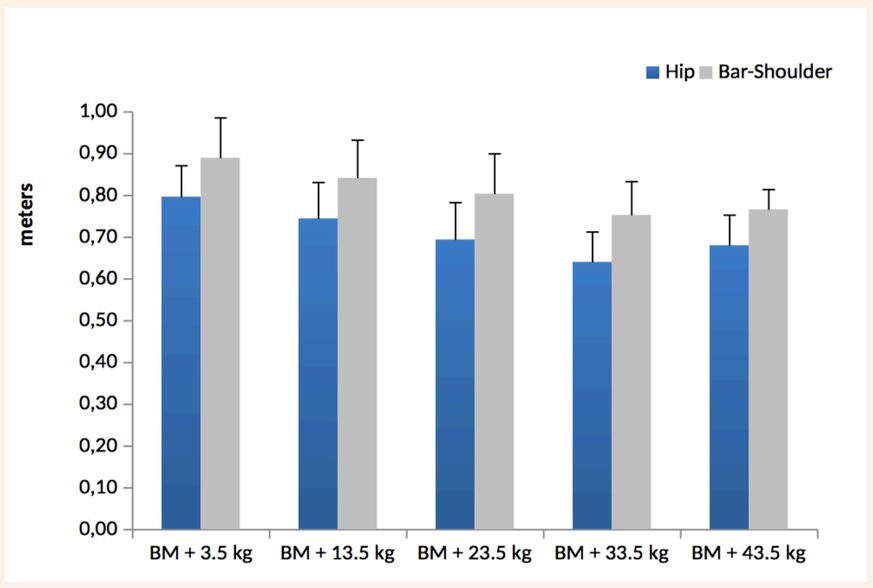

Fig. 2 bar displacement (m) of hip and shoulders
*p<0.01

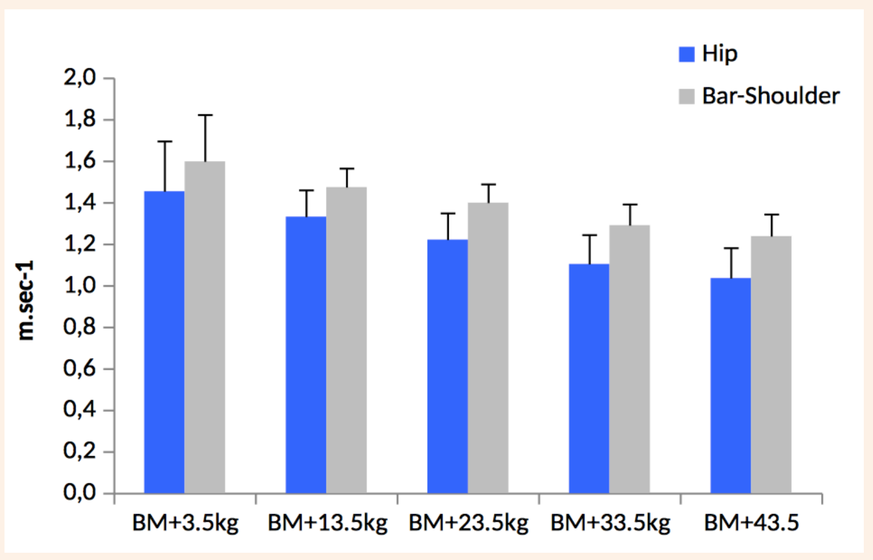

Fig. 3. average velocity (m.sec-1) measured by the markers placed at hip and shoulders levels.

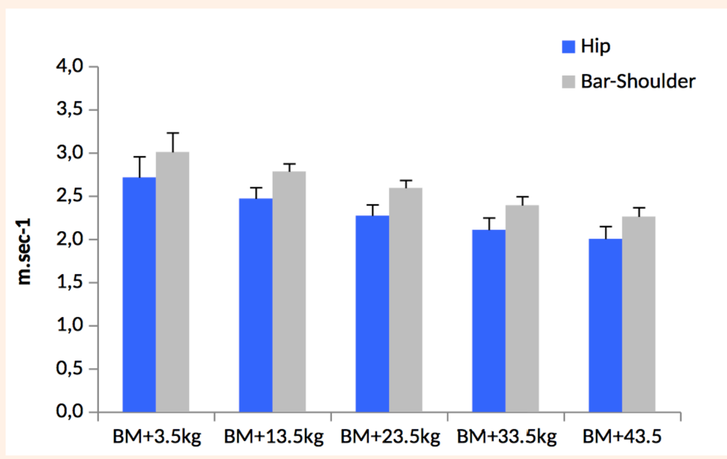

Fig. 4. peak velocity (m.sec-1) measured by the markers placed at hip and shoulders levels.

Discussion:
The correct placement of the anatomical markers to be analyzed in the determination of the body displacements seems to be a vital consideration when assessing vertical jump performance in athletes (e.g., shoulders would underestimate the height of the jump by more than 11% regardless of the overload). Coaches and athletes are advised to use similar methodologies over repetitive assessments and to select the most appropriate criteria for evaluating performance in athletes.

Conclusion:
During the CMJ the hip moves up over a shorter trajectory and achieves lower velocity compared to the shoulders. As the marker situated around the hip is closer the center of mass of the dynamic unit, coaches are encouraged to use the trajectory of the hip over that of the shoulders or the barbell for properly assessing CMJ performance.

References
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