Comparison between the trajectory and movement velocity of shoulders vs. hip in squat

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Introduction:

The squat is one of the most popular core exercises utilized by athletes to enhance performance in sport (4). Many coaches in different disciplines consider squat performance for assessing athlete's lower body conditioning and consequently designing resistance-training programmes (2). Several investigations have proposed the use of position or velocity transducers attached to the bar to measure the displacement and calculate the velocity and power to monitor athletic performance during squatting exercises (3,4).

Purpose:

The aim of this study was to compare the vertical displacement and velocity of the shoulder and hip during the deep squat exercise performed with light, to moderate loads

Materials and methods:

After 1 day of familiarisation, twenty-six men (age 29.1±3.2 years; body mass 75.9±7.32 kg; height 177.7±6.1 cm) completed a progressive resistance test on a smith machine, which consisted of 6 sets of 3 repetitions performed with maximal acceleration and alternated with 2 to 3 minutes of rest. The participants squatted against loads of 20; 30; 40; 50; 60 and 70 kg. These absolute loads represented an equivalent mean resistance of <20%, 26, 38, 45%, 55 and 65% of the estimated 1RM. 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 were used to estimate the displacement and the velocity achieved by the hip (X) and shoulders (Y) during the ascending phase of the deep squat.

Statistical analysis

Pearson product-moment correlation was applied to determine associations between the compared variables (displacement, average mean, propulsive and peak velocity). Six 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.

Delta scores (Δ) were calculated by the following equation [(values from the shoulders-values from the hip/values from the hip)*100]; the scores were thus interpreted as percentages and used for determining relative differences in the measured variables when comparing values from hip vs. values from shoulders.

References

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Results:

Significant ($p<0.001$) shorter displacement (Figure 2) and lower average mean, propulsive and peak velocities 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.

The calculated delta score demonstrated higher displacement (Figure 2) and velocities (Figure 3) of the markers place in the shoulders compared to the markers placed on the hips.

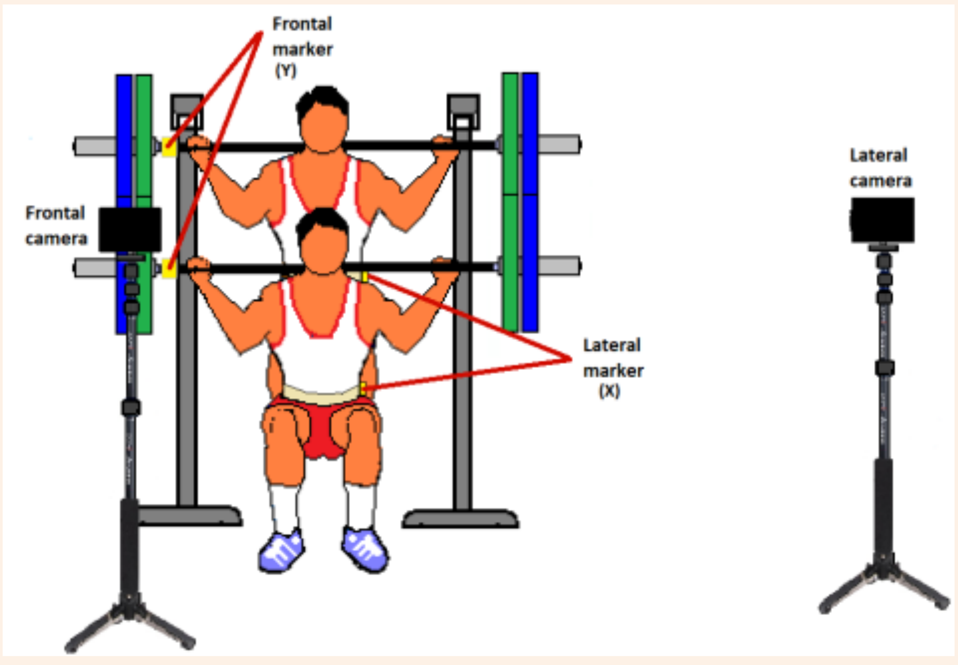


Fig. 1 The Velowin® system using two cameras for measuring the trajectory of the bar and centre of gravity during the deep squat

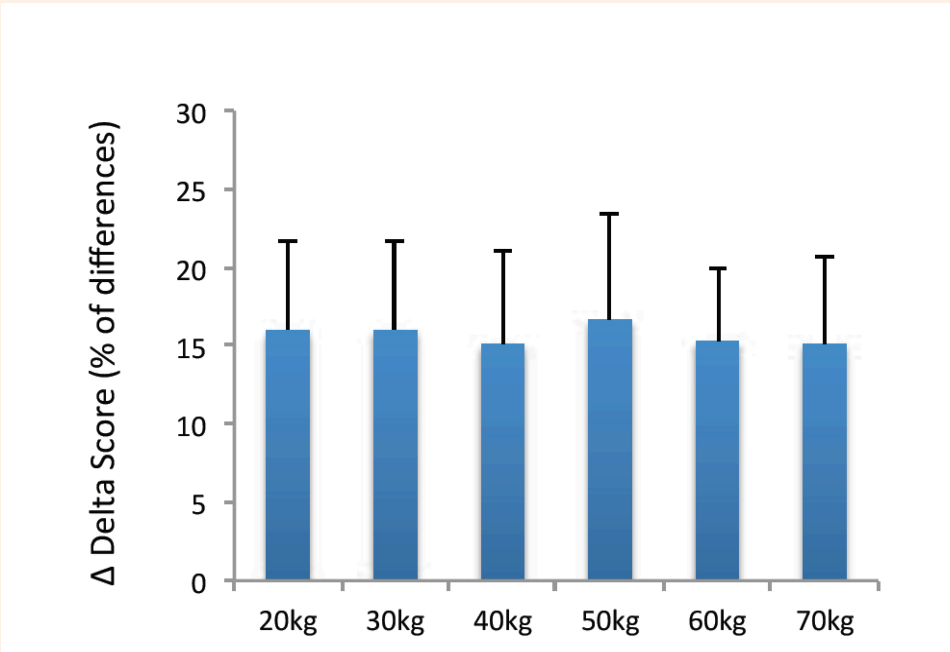
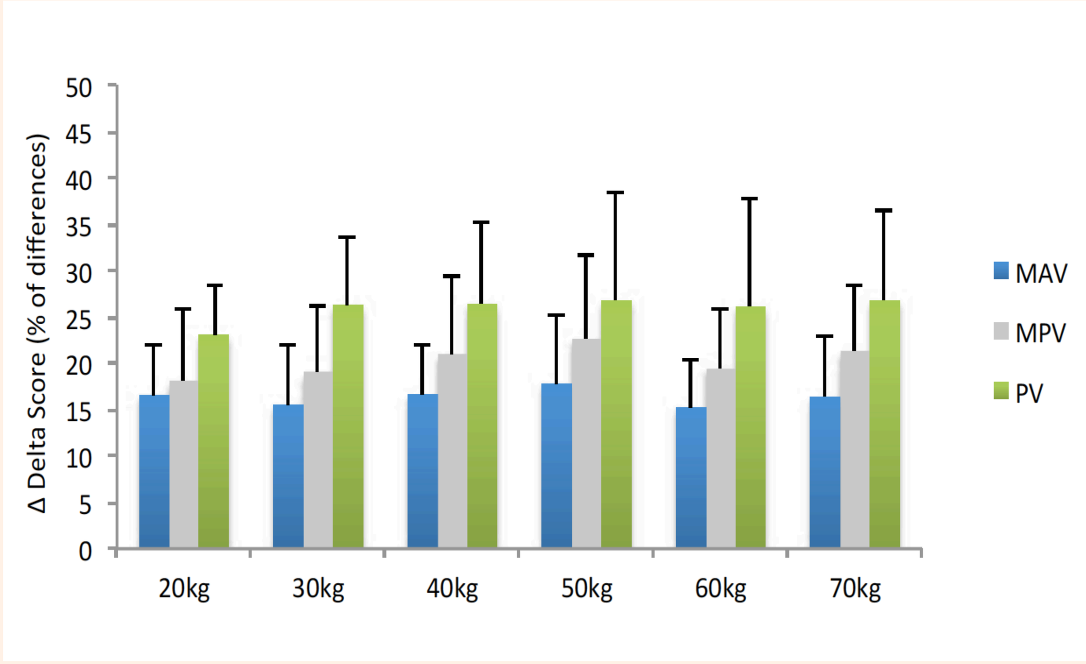


Fig. 2. Delta Score (Δ) calculated for the displacement



Δ Delta Score (Δ) calculated for the average mean, propulsive and peak velocity measured by the markers placed at shoulder vs. hip during deep squat

Notes: MAV: mean average velocity, MPV: mean propulsive velocity, PV: peak velocity

Discussion:

The correct placement of the anatomical markers to be analyzed during resistance exercise such as squat is an essential methodological consideration. E.g., using markers placed on the shoulders will overestimate the mean average, propulsive and peak velocity of the dynamic unit by about 15%, 20 and 25% respectively regardless of the load.

Conclusion:

During the deep squat, the hip moves over a shorter trajectory and achieves lower velocity compared to the shoulders. As the marker situated around the hip is closer the centre of mass of the dynamic unit, it is suggested that the hip and not the shoulder or barbell should be considered the reference marker for estimating the mechanical performance during the squat.