Supplemental Digital Content 3: Instrumented Barbell

We used a custom-made instrumented barbell with two built-in force transducers to measure the horizontal forces applied by the lifter to the bar (Figure 3). Prior to participant recruitment, the instrumented barbell was calibrated, and its accuracy assessed. Loads with known masses up to 30kg and in 5kg increments were attached to the barbell, such that each force transducer was subjected to static medial and lateral forces. Linear relationships between the applied load and the voltage output of the force transducers were found for both sensors (Figure 6). Linear regression equations (R-squared = 1.0) were established and used to convert voltage into force (N) during data processing. After data collection, the same calibration procedure was performed, yielding almost identical regression equations. Further, force values from the barbell and a force plate were compared when holding the barbell, at one of the designated grip areas, in a vertical position above the ground while standing on the force plate. Errors were ≤ 5% for medial and lateral force directions for both sensors. We also tested and compared the left and right force transducers during performance of static and dynamic bench press variations with different grip widths, loads and friction forces. Deviations between sensors were ≤ 6%.
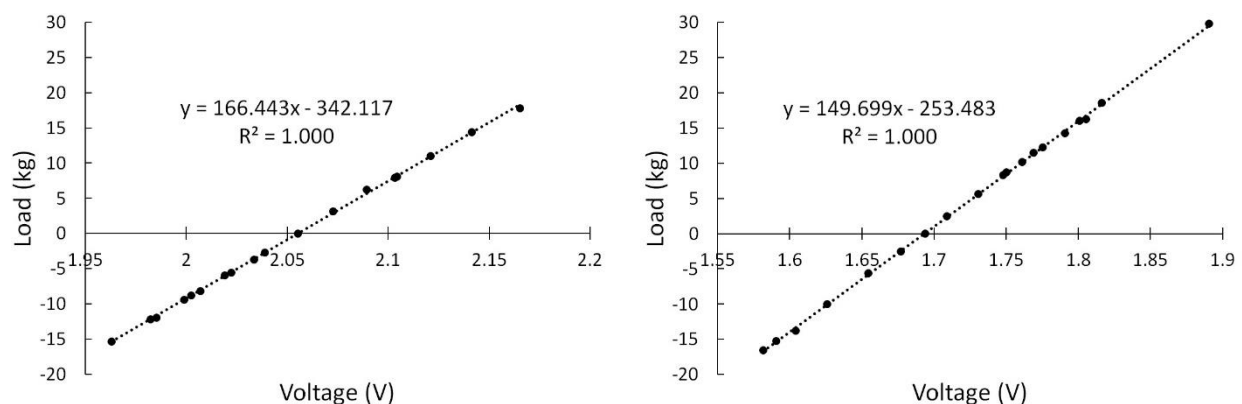

Figure 6. Calibration data for the two force transducers of the instrumented barbell. Trendline (dotted), individual data points (circles) and linear regression equation with R-squared of sensor A (left) and sensor B (right). Positive values on the y-axis indicate lateral force application.