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Technical Note on the Reliability of the PowerLift App for Velocity-Based Resistance Training Purposes: Response

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Associate Editor Jane Grande-Allen oversaw the review of this article.

Dear Editor,

Thank you for the opportunity to respond to the points raised in this letter from Mr. Balsalobre regarding our recent article.[3] We appreciate the interest shown in our study. However, it seems that this author has misunderstood some points about the reliability analyses that we conducted and, therefore, this needs to be clarified. Our study[3] aimed to analyze the agreement between five bar velocity monitoring devices, currently used in resistance training, to determine which was the most reliable device based on the results of reproducibility (between-device agreement for a given trial) and repeatability (between-trial variation for each device) analyses. Among the five different technologies assessed, only the data regarding the *PowerLift* smartphone app have been questioned by the author. It should be noted that this author is the main developer of the *PowerLift* app and the main author of the paper in which it was allegedly validated.[2]

The arguments put forward by the author to question our results are based on the assumption that ‘‘the observers who performed the video analysis did not use the app properly, because, following their data, the raw difference in frames would be higher that 20–30 frames’’. As clearly detailed in our manuscript,[3] ‘‘*Intra-device* reproducibility was assessed by comparing the velocity outcomes for trial 1 simultaneously obtained by each pair of the *two (same brand and model) devices*’’. Thus, the results we presented here were obtained using two same version *PowerLift* apps (v 4.0 iOS) installed on two iPhone 6 units running iOS 11.3, and *analyzed by the same examiner*. Notwithstanding the above, in the letter, the author noted ‘‘Specifically, in powerlifting exercises like the bench-press, observers need to manually select the frames in which the bar takes-off the chest (beginning of the lift) and stops its vertical ascent (end of the lift). Because of that, previous research analyzing the validity and reliability of VBS [video-based systems] compared to scores of *two observers* analyzing the same videos in order to detect the *inter-observer* variability’’. Thus, it seems that the author has confused the concept of ‘‘intra-device agreement’’ (i.e., comparing the outcomes *simultaneously obtained by two devices* for a given trial) with the concept ‘‘inter-observers’ agreement’’ (i.e., comparing the outcomes obtained by *two observers* for a given video file in the same smartphone). It should be noted that we were fully aware of the need of counting both with experienced examiners and reproducible procedures to ensure the quality of the measures, particularly in manually operated systems such as the *PowerLift* app. In our study,[3] the examiner showed an excellent reliability when he analysed the same video file, in the same smartphone, in two separate occasions (ICC > 0.997, 95% ICC 0.984–1.000; CV < 3.02%), which are values higher than those reported in previous investigations where the smartphone was hold in the hands.[1,2] We therefore agree that the *PowerLift* is very easy to use and reliable in terms of intra-observers’ agreement. However, this was clearly not the hypothesis tested in our investigation, which leads us to think that the author has not read the study carefully. The two main goals of our work[3] were: (1) to identify the errors arising from current velocity monitoring tech-

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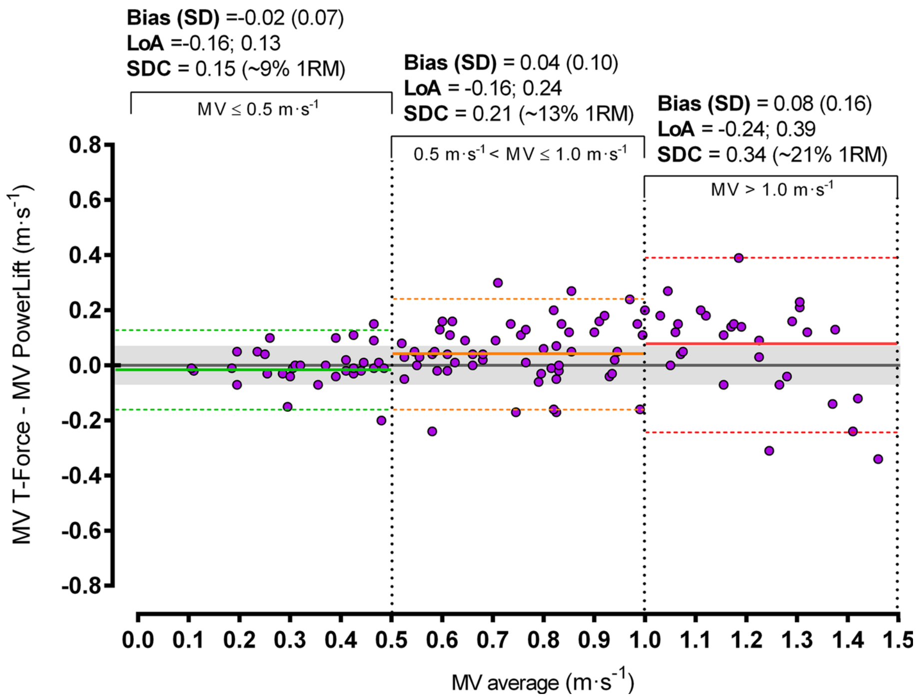

FIGURE 1. Bland–Altman plots showing between-device agreement (T-Force vs. PowerLift) in mean velocity (MV) for trial 1 in the bench press exercise. Magnitude of errors correspond to MV ≤ 0.5 m s^{-1} (green lines), 0.5 m s^{-1} < MV ≤ 1.0 m s^{-1} (yellow line) and > 1.0 m s^{-1} (red line). *LoA* limits of agreement, *SDC* smallest detectable change. Area shaded in grey indicates an acceptable level of agreement between devices (Data pertaining to the study by Courel-Ibáñez *et al.*[3]).

nologies (intra-device reproducibility and repeatability) to determine which was the most reliable (i.e., which, in turn, could be taken as the gold standard or reference device), and (2) to objectively quantify the agreement between measurements from each device against that gold standard.[3] This approach is inspired by the need of comprehensive information to guarantee the suitability of emerging devices (based on new technologies) in order to identify whether the changes observed in velocity against certain workloads are due to changes in athletes' performance or are due to measurement error.[5] We believe this is invaluable information to both coaches and practitioners in order to be able to determine the real effort being incurred during resistance exercise.

We would like to take this opportunity to clarify that what our results show is a very poor reliability of the *PowerLift* measurements in terms of intra-device (i.e., between two smartphones for a given trial or execution) and inter-device (i.e., between the *T-Force System* linear velocity transducer and one smartphone running the *PowerLift* app for a given trial) agreement when monitoring the full load-velocity relationship (i.e., broad spectrum of mean bar velocity values, from < 0.10 to > 1.50 m s^{-1}). In this regard, the author provided a list of studies examining other physical skills such as the running mechanics or vertical jump by using specific apps for these purposes. However, we are not questioning the use of these apps but the *PowerLift* as a monitoring tool for velocity-based resistance training purposes. In a more appropriate manner, the author cited three studies which used the *PowerLift*[1,2,8]; in two of them, the main author was himself, the developer of the app, Mr. Balsalobre.[1,2] While none of these studies provided data about the intra-device agreement, the three of them examined the inter-device agreement of the *PowerLift* against a supposedly gold standard. There are two main points to clarify here. Firstly, these three studies considered as their gold standard a different device (Smartcoach encoder[1,2] and a 3D motion analysis system[8]) than that taken by us (T-Force System) to assess the concurrent validity of the *PowerLift* app. To the best of our knowledge, there is no available information about the inherent technical errors, standard error of the measurement or minimal detectable changes, associated to any of those devices for bar velocity measurement during resistance exercise, unlike the evidence reported by us for the T-Force System device.[3] Consequently, comparisons of our results with those reported earlier must be done with extreme caution. Secondly, these three studies[1,2,8] only included data from resistance exercises performed at slow[2] (< 0.50 m s^{-1}) or moderate (< 1.00 m s^{-1}) velocities,[1,8] when compared to a much broader load-velocity spectrum analyzed in our study[3] (from 0.10 to > 1.50 m s^{-1}). With the above-mentioned caution, if we divide the full load-velocity relationship into three segments or parts of 0.50 m s^{-1} (Fig. 1, example for the bench press exercise; data from Courel-Ibáñez *et al.*[3]), it can be observed that our findings partially agree with those earlier reported suggesting the use of the *PowerLift* for measuring high loads at slow velocities (< 0.50 m s^{-1}), with a modest margin of error (e.g., bench press: SDC = 0.15 m s^{-1}, ~ 9% 1RM, Fig. 1; full squat: SDC = 0.12 m s^{-1}, ~ 8% 1RM). The main problem here is that mean velocities < 0.50 m s^{-1} are associated with extremely high loads for the most common resistance training exercises (> 80% in bench press,[5,9] 90% in full squat[10] or even > 100% in prone bench pull[9]), which limits its practical application. More importantly, we found that the reliability of the app drastically decreased as mean lifting velocity increased, with the highest errors occurring for lifts performed at velocities > 1.00 m s^{-1} (SDC 0.34 m s^{-1}, 21% 1RM; Fig. 1). We consider this fact a limitation for velocity-based resistance-training purposes as the range of velocities that can be monitored with sufficient sensitivity is greatly reduced. More importantly, monitoring high velocities (≥ 1.00 m s^{-1}) should be preferable to assess changes in neuromuscular and functional performance due to the higher specificity in relationship with most sporting movements.[4,6,7]

Finally, the author of the letter mentioned our lack of knowledge to use the *PowerLift* app because we did not evaluate the prone bench pull exercise. We respectfully disagree, and we must clarify that the pre-customized mode and the specific algorithm for the prone bench pull exercise was not available when the data were collected (*PowerLift* v. 4.0 iOS).

Taken into account all of the above, and according to what we detailed in the original paper,[3] we sustain that the *PowerLift* smartphone app should be not recommended as a monitoring tool for velocity-based resistance-training, given the substantial errors incurred and uncertainty of the outcomes obtained. There is no doubt that the intentions to develop smartphone apps as cheaper methods to measure bar velocity are laudable. In this same line, we have identified quite good alternatives to linear velocity transducers for ~ 550 €. But whatever the price, unless a measurement device provides enough accurate and reliable measurements, its use should be discouraged. If a device lacks enough sensitivity and the errors incurred when using it exceed a certain magnitude (see the concepts of smallest detectable change and maximum error in our original study[3]) the device renders completely useless for its intended purpose. Now more than ever, in this era where we are experiencing the apps, gadgets and wearables booms, we must be very critical when choosing our measurement instruments.

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