UDC: 681.586-049.8:[796.015.13-026.51:796.071.2-057.875](73)
Original scientific paper

AGREEMENT BETWEEN VITRUVE AND TENDO LINEAR POSITION TRANSDUCERS FOR ASSESSING MEAN AND PEAK VELOCITY DURING CLEAN AND SNATCH HIGH PULLS IN COLLEGIATE ATHLETES

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Abstract

Linear position transducers (LPT) are widely used to measure barbell velocity, a key metric in weightlifting movements such as snatch high pulls (SHP) and clean high pulls (CHP), which offer notable sports performance benefits. The purpose of this study was to examine the agreement between the Vitruve and Tendo LPTs for assessing mean and peak barbell velocity during clean high pulls (CHP) and snatch high pulls (SHP) performed at submaximal loads in collegiate athletes. Eighteen Division III athletes completed three laboratory visits. During the first visit, one-repetition maximum (1RM) values were established for the CHP and SHP. During the subsequent visits, participants performed single repetitions at 50%, 60%, 70%, and 80% of 1RM while barbell velocity was recorded simultaneously by both devices. Paired t-tests, effect sizes, Bland–Altman analyses, and regression of the difference scores versus the means were used to examine between-device differences, agreement, and proportional bias. No significant between-device differences were observed for CHP mean velocity, CHP peak velocity, or SHP mean velocity across the relative loads (all $p > 0.05$). In contrast, SHP peak velocity measured by Vitruve was lower than Tendo at 50% and 60% 1RM ($p < 0.01$), with the same directional pattern displayed at 70% and 80% 1RM. Bland–Altman analyses showed small mean biases for mean velocity across both lifts, whereas larger negative biases were evident for SHP peak velocity. Significant proportional bias was only observed for SHP mean velocity at 50% and 70% 1RM. These findings indicate that Vitruve and Tendo provide comparable mean velocity values during CHP and SHP performed at submaximal loads. Peak velocity should be interpreted more cautiously, particularly during the SHP at lighter loads. From an applied standpoint, mean velocity appears to be the more stable metric when comparing these devices during Olympic-derived pulling exercises.

Keywords: velocity-based training; linear position transducer; Tendo; Vitruve; clean high pull; snatch high pull

1. Introduction

Velocity-based training (VBT) has become a widely used method for prescribing and monitoring resistance exercise intensity, given that barbell velocity provides a practical index of neuromuscular performance and daily readiness (Vernon *et al.*, 2020; Weakley *et al.*, 2021*a*). Rather than relying exclusively on percentages of one-repetition maximum (1RM), VBT allows coaches to adjust training loads based on the actual speed of the movement. As a result, the quality of the information provided by the measuring device becomes crucial to the quality of the training decision (González-Badillo & Sánchez-Medina, 2010; Callaghan *et al.*, 2022; Muñoz De La Cruz *et al.*, 2023; Kilgallon *et al.*, 2025).

Among commercially available systems used in VBT, linear position transducers (LPTs) remain favored because they generally demonstrate stronger validity and reliability compared to other portable technologies for estimating barbell velocity. Nonetheless, agreement cannot be

assumed across devices. Device-specific differences have been reported across exercises, loading zones, and velocity ranges, and these differences appear to be magnified in faster and more ballistic movements (Thompson *et al.*, 2020; Callaghan *et al.*, 2022; Moreno-Villanueva *et al.*, 2024). For that reason, field-based validation and agreement work remains necessary, particularly when lower-cost systems are introduced into applied settings.

The Tendo Power Analyzer has been widely used in research and practice and remains one of the most established field-based systems for monitoring barbell velocity. The Vitruve LPT has emerged as a less expensive alternative and gained popularity because it provides immediate feedback through a mobile application and allows practitioners to monitor several velocity-derived variables. Recent work examining the Vitruve has shown promising concordance in some exercise conditions, but mixed validity relative to established devices has also been reported, particularly when exercise mode and velocity range vary (Gonzalez *et al.*, 2019; González-Galán *et al.*, 2024; Ruiz-Alias *et al.*, 2024). Consequently, the practical interchangeability of Vitruve with more established devices remains unresolved.

This question is especially relevant in Olympic-derived pulling exercises. Weightlifting pulling derivatives, such as the clean high pull (CHP) and snatch high pull (SHP), are commonly used to develop force and movement velocity while reducing the technical demands of the catch phase in the full Olympic lifts. Given that these exercises are intended to be performed explosively and are frequently monitored using velocity-based methods, they provide an appropriate context for evaluating whether two devices generate comparable outputs (Suchomel *et al.*, 2015, 2023; Suchomel & Sole, 2017).

Although barbell velocity monitoring has been studied in more traditional resistance exercises (e.g., squat, bench press), fewer studies have examined device agreement during Olympic-derived pulling derivatives, and even fewer have addressed the Vitruve, specifically, in this context. Therefore, the purpose of this study was to examine the agreement between the Vitruve and Tendo LPTs for mean and peak barbell velocity during the CHP and SHP performed at 50%, 60%, 70%, and 80% 1RM in collegiate athletes. It was hypothesized that mean and peak velocity would demonstrate strong between-device agreement across both lifts and all loading conditions.

2. Methods

2.1 Subjects: Eighteen Division III collegiate athletes (7M, 11W; 21 ± 0 years; 171 ± 6 cm; 69 ± 1 kg) from basketball and hockey programs at Aurora University volunteered to participate. Collegiate athletes were selected because they represent a trained population familiar with resistance training and Olympic-style movements, which are commonly incorporated into their sport-specific training. All participants in the current study were familiarized with Olympic-derived pulling derivatives (i.e., CHP and SHP) for at least 6 months prior to data collection as part of their regular strength and conditioning programs created by the Aurora University strength and conditioning staff. Exclusion criteria included cardiovascular, orthopedic, or other conditions that would limit safe participation in weightlifting exercise. Prior to testing, all subjects completed a health history questionnaire and provided written informed consent. The study was approved by the Aurora University Institutional Review Board (#1216).

2.2 Experimental Design: A randomized crossover design was utilized in this investigation. Each subject completed three visits over approximately 2 to 3 weeks, with at least 48 h between visits. During the first visit, 1RM values in CHP and SHP exercises were assessed. During visits 2 and 3, participants completed the load–velocity testing sessions for the CHP and SHP in randomized order (Figure 1). During each repetition, barbell velocity was measured simultaneously by the Vitruve and Tendo devices. Participants were instructed to avoid

strenuous exercise in the 24 h preceding each test session. Activity level was controlled by recruiting collegiate athletes who were actively participating in structured training programs led by the Aurora University strength and conditioning staff. Additionally, all participants were in their off-season during testing. All experimental procedures were performed at approximately the same time of day (±2 h) for each participant.

2.3 Procedures: Each testing session began with a standardized 5 min dynamic warm-up followed by a PVC pipe-based weightlifting mobility routine. The warm-up was supervised by the strength and conditioning staff to promote consistent movement preparation and technical execution across visits.

During visit 1, subjects completed a 1RM assessment for both the CHP and SHP. The protocol progressed from submaximal warm-up sets to progressively heavier single attempts until the highest successful lift performed with acceptable technique was obtained. Rest periods of 2–4 min were provided between sets and attempts. 1RM testing of CHP was always completed before 1RM testing of SHP in all participants.

During visits 2 and 3, subjects performed the assigned pulling derivative at 50%, 60%, 70%, and 80% of their previously established 1RM. Three single repetitions were completed at each relative load, with 1 min of rest between repetitions and 2 min of rest between loads. All repetitions were performed from a static start and were supervised to maintain consistent technique and minimize unwanted countermovement.

Barbell velocity was measured simultaneously using the Vitruve and Tendo LPTs. The devices were attached to opposite ends of the barbell for each trial, and staff verified that both tethers were vertically aligned before each repetition. Mean velocity and peak velocity were recorded from each device for every repetition. The Vitruve values were monitored through the manufacturer's mobile application, whereas the Tendo values were displayed on the handheld receiver and recorded manually.

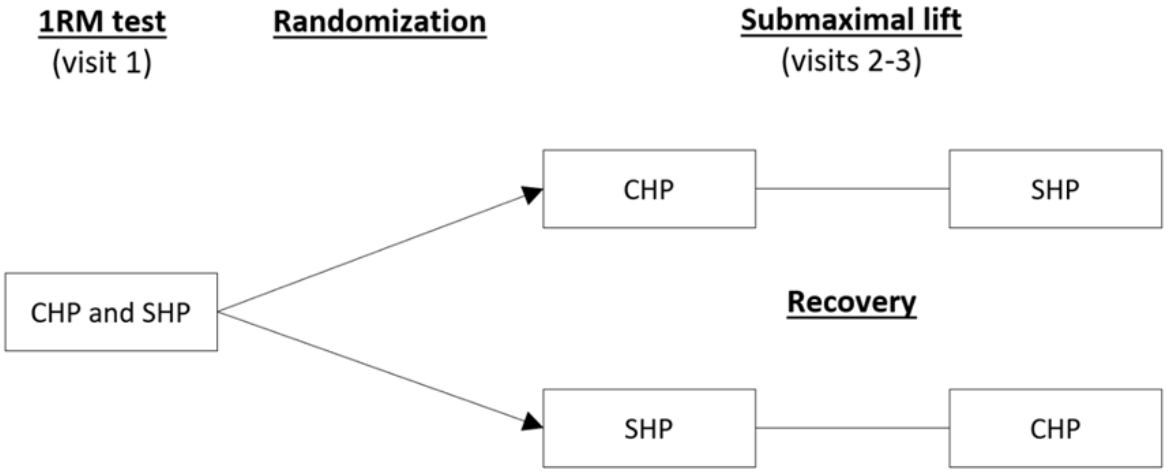


Figure 1. Flow diagram representing the study design. 1RM, one-repetition maximum; CHP, clean high pull; SHP, snatch high pull.

2.4 Statistical Analysis: All data were recorded in Microsoft Excel (Microsoft Corporation, Redmond, WA) and later transferred and analyzed using SigmaPlot 14.5 (Systat Software, San Jose, CA). Paired t-tests were used to determine whether systematic differences existed between Vitruve and Tendo at each load (50%, 60%, 70%, 80% 1RM) for each outcome (mean velocity and peak velocity). Effect sizes were used to provide a practical interpretation of the magnitude of the between-device differences. Agreement was further examined using Bland–Altman analyses, with the mean bias calculated as Vitruve − Tendo and the 95% limits of agreement calculated as the mean bias ± 1.96 SD of the paired differences. Simple linear regression of the

Bland–Altman difference scores versus the means was used to examine proportional bias. Statistical significance was set a priori at $\alpha = 0.05$. All values are presented as means ± SE.

3. Results

CHP and SHP 1RM and submaximal loads are displayed in Table 1. Descriptive data for CHP and SHP are shown in Tables 2 and 3, respectively. Bland–Altman plots for CHP mean velocity, CHP peak velocity, SHP mean velocity, and SHP peak velocity are shown in Figures 2-5, respectively.

Table 1. CHP and SHP 1RM and submaximal load (kg).

Clean High Pull, kg					**Snatch High Pull, kg**				
1RM	50% 1RM	60% 1RM	70% 1RM	80% 1RM	1RM	50% 1RM	60% 1RM	70% 1RM	80% 1RM
69 ± 5	34 ± 2	41 ± 3	48 ± 3	55 ± 4	66 ± 4	33 ± 2	40 ± 2	46 ± 3	53 ± 3

Values are means ± SE. 1RM, one-repetition maximum.

3.1 Clean High Pull: No significant between-device differences were observed for CHP mean velocity at 50%, 60%, 70%, or 80% 1RM (p = 0.077–0.841). The absolute differences between devices were small across all loads, with Vitruve producing slightly higher mean velocities at 50–70% 1RM and nearly identical values at 80% 1RM. Bland–Altman analyses showed small mean biases ranging from 0.036 to −0.003 m/s, with no evidence of proportional bias at any load.

Similarly, no significant between-device differences were detected for CHP peak velocity (p = 0.134–0.477). Vitruve produced slightly lower peak velocity values than Tendo at each load, but the mean biases remained small (approximately −0.043 to −0.011 m/s). Regression analyses of the Bland–Altman plots did not reveal proportional bias for CHP peak velocity.

Table 2. CHP mean and peak velocity (m/s) measured by the Vitruve and Tendo devices.

	Mean Velocity (m/s)					**Peak Velocity (m/s)**				
Load (% 1RM)	**Vitruve**		**Tendo**		**p-value**	**d_z**	**Vitruve**		**Tendo**		**p-value**	**d_z**
50%	1.71 ± 0.06		1.67 ± 0.05		0.077	0.44	2.56 ± 0.06		2.60 ± 0.06		0.134	-0.37
60%	1.57 ± 0.05		1.54 ± 0.05		0.142	0.36	2.35 ± 0.06		2.38 ± 0.06		0.176	-0.33
70%	1.45 ± 0.04		1.43 ± 0.04		0.262	0.27	2.17 ± 0.05		2.20 ± 0.04		0.169	-0.34
80%	1.31 ± 0.04		1.32 ± 0.04		0.841	-0.05	2.03 ± 0.04		2.04 ± 0.04		0.477	-0.17

Values are means ± SE. 1RM, one-repetition maximum.

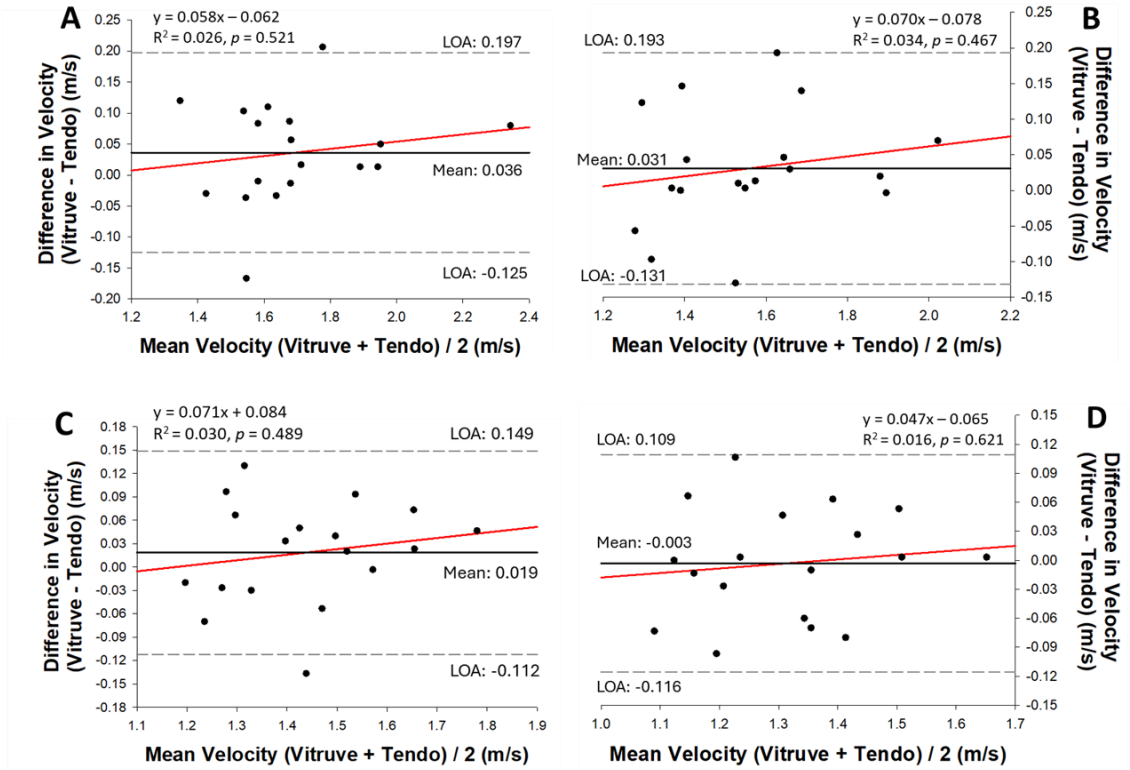


Figure 2. Bland–Altman plots for CHP mean velocity (m/s) at 50% (A), 60% (B), 70% (C), and 80% 1RM (D). The solid line represents the mean bias (Vitruve − Tendo), and the dashed lines represent the 95% limits of agreement.

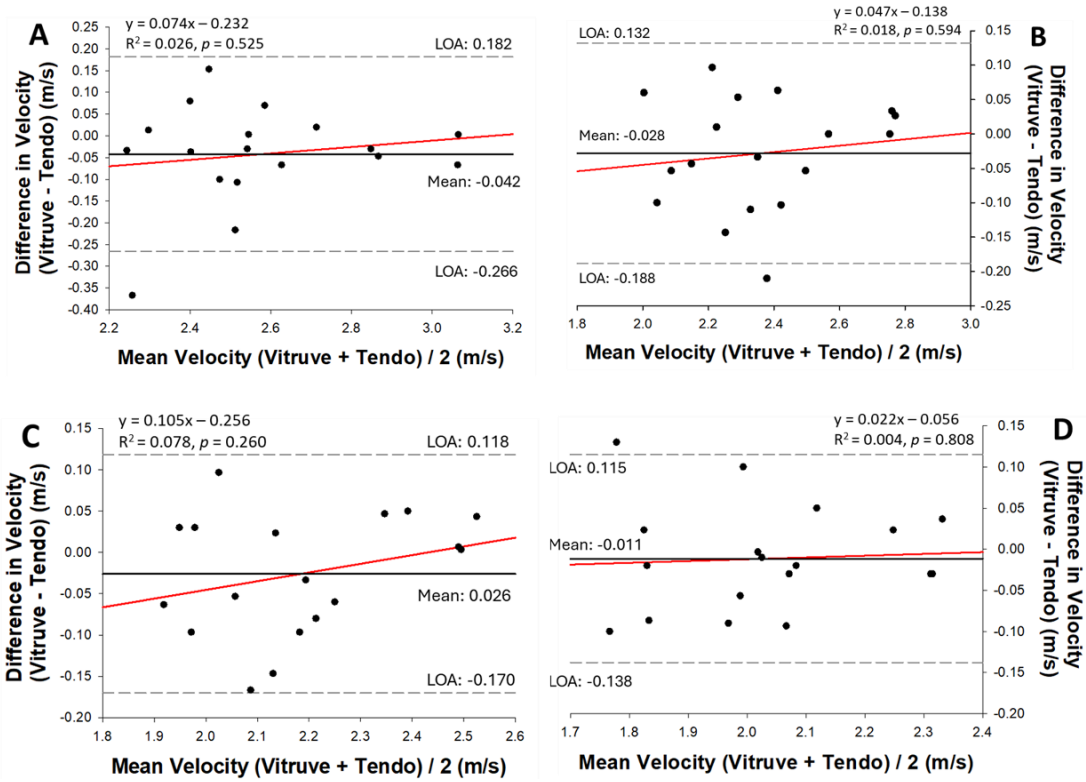


Figure 3. Bland–Altman plots for CHP peak velocity (m/s) at 50% (A), 60% (B), 70% (C), and 80% 1RM (D). The solid line represents the mean bias (Vitruve − Tendo), and the dashed lines represent the 95% limits of agreement.

3.2 Snatch High Pull: No significant between-device differences were observed for SHP mean velocity at any load (p = 0.206–0.970). The mean biases were minimal, ranging from 0.000 to −0.012 m/s. However, regression of the Bland–Altman difference scores versus the means indicated significant proportional bias at 50% (R^2 = 0.279, p = 0.024) and 70% 1RM (R^2 = 0.268, p = 0.028), whereas 60% and 80% 1RM did not demonstrate proportional bias.
For SHP peak velocity, Vitruve produced lower values than Tendo across all loading conditions. Significant between-device differences were observed at 50% 1RM (p < 0.001) and 60% 1RM (p = 0.008), with similar directional differences present at 70% (p = 0.084) and 80% 1RM (p = 0.051). Bland–Altman analyses showed negative mean biases at all loads (approximately −0.075 to −0.033 m/s), indicating that Vitruve consistently underestimated peak snatch velocity relative to Tendo. No proportional bias was detected for SHP peak velocity.

Table 3. SHP mean and peak velocity (m/s) measured by the Vitruve and Tendo devices.

	Mean Velocity (m/s)						Peak Velocity (m/s)					
Load (% 1RM)	**Vitruve**		**Tendo**		**p-value**	**dz**	**Vitruve**		**Tendo**		**p-value**	**dz**
50%	1.64 ± 0.05		1.64 ± 0.04		0.970	0.01	2.56 ± 0.06		2.63 ± 0.06		<0.001	-0.91
60%	1.49 ± 0.05		1.50 ± 0.05		0.710	-0.08	2.34 ± 0.06		2.39 ± 0.06		0.008	-0.71
70%	1.39 ± 0.04		1.40 ± 0.03		0.561	-0.13	2.17 ± 0.05		2.21 ± 0.05		0.084	-0.43
80%	1.26 ± 0.03		1.27 ± 0.03		0.206	-0.29	2.01 ± 0.04		2.04 ± 0.05		0.051	-0.51

Values are means ± SE. 1RM, one-repetition maximum.

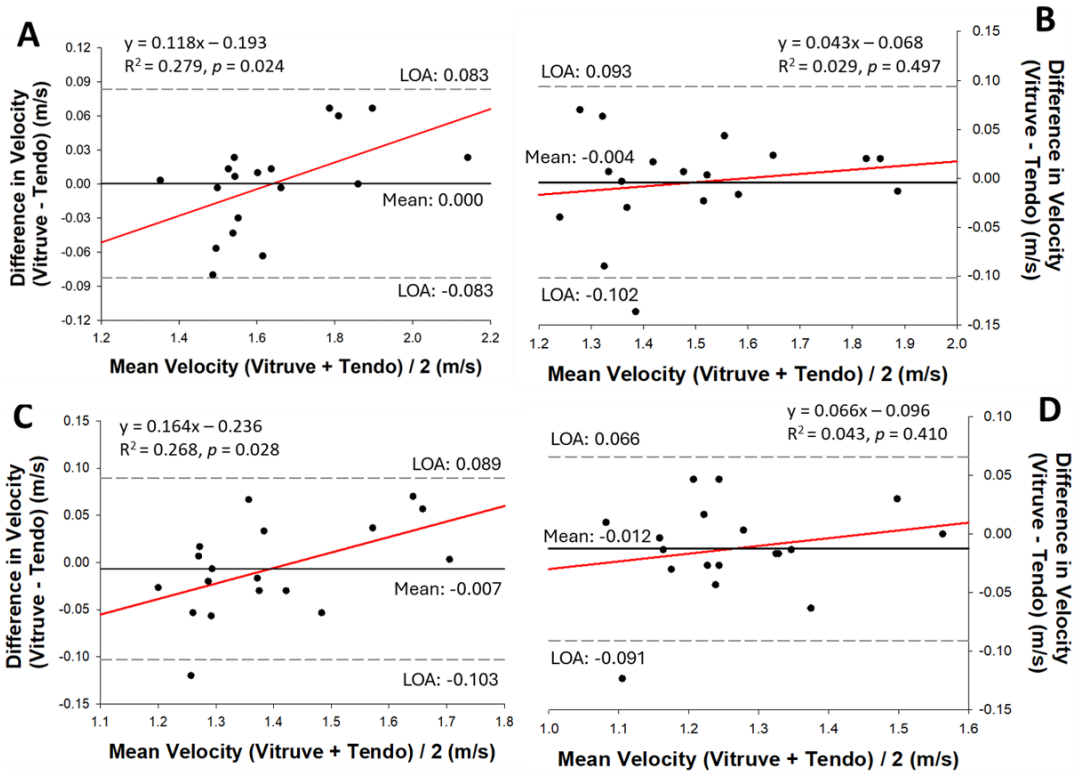


Figure 4. Bland–Altman plots for SHP mean velocity (m/s) at 50% (A), 60% (B), 70% (C), and 80% 1RM (D). The solid line represents the mean bias (Vitruve − Tendo), and the dashed lines represent the 95% limits of agreement.

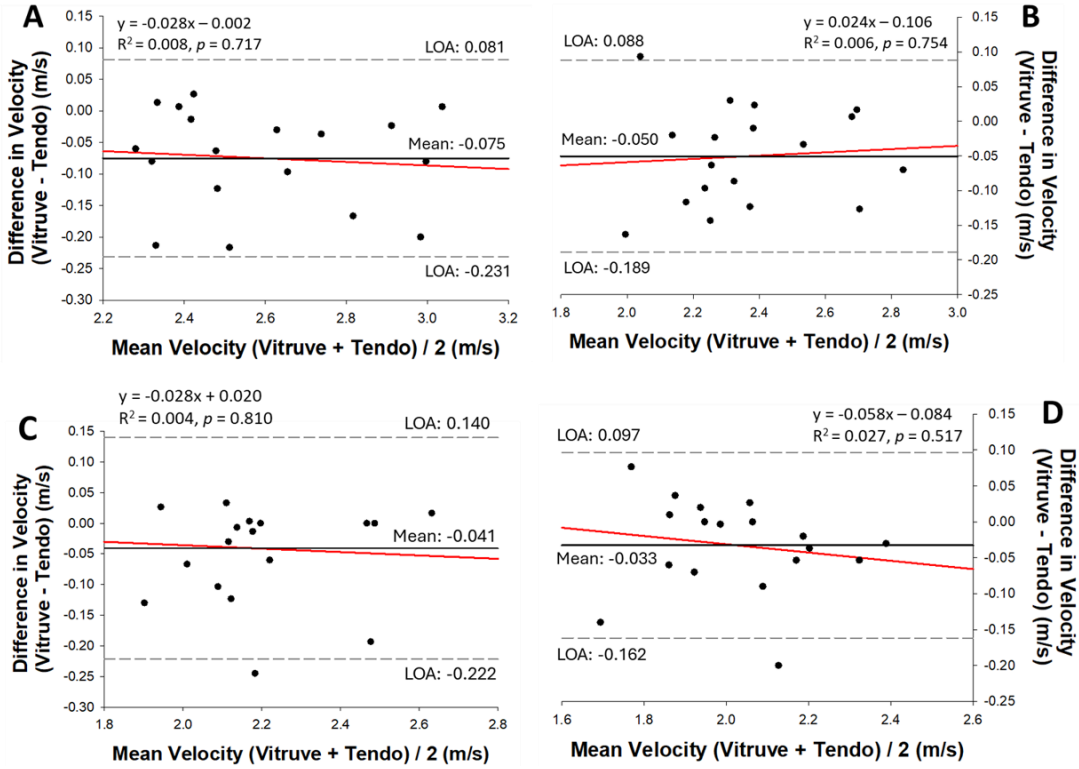


Figure 5. Bland–Altman plots for SHP peak velocity (m/s) at 50% (A), 60% (B), 70% (C), and 80% 1RM (D). The solid line represents the mean bias (Vitruve − Tendo), and the dashed lines represent the 95% limits of agreement.

4. Discussion

The purpose of this study was to examine the agreement between the Vitruve and Tendo LPTs for mean and peak barbell velocity during CHP and SHP exercises performed at submaximal loads in collegiate athletes. Our primary finding was that mean velocity demonstrated closer agreement between devices than peak velocity. Another finding was that agreement was stronger during the CHP than during the SHP. Together, these results indicate that the practical comparability of the two devices depends on both the velocity metric being used and the movement being performed.

The strongest agreement was observed for mean velocity. Across all CHP loads and all SHP loads, mean velocity did not differ significantly between devices, and the absolute between-device biases were small. From a practical standpoint, this is a crucial finding because mean velocity is one of the most commonly used variables in daily load prescription, readiness monitoring, and fatigue management in applied VBT settings (González-Badillo & Sánchez-Medina, 2010; González-Badillo *et al.*, 2011; Jukic *et al.*, 2023). If a practitioner is using high-pull derivatives as part of a velocity-based program, the current data suggest that mean velocity from Vitruve and Tendo will generally tell a similar story.

Conversely, peak velocity showed greater between-device discrepancies, particularly during the SHP. Vitruve consistently produced lower peak velocity values than Tendo, and the differences were statistically significant at 50% and 60% 1RM, with the same directional pattern remaining at 70% and 80% 1RM. This distinction between mean and peak velocity is not surprising. Mean velocity reflects performance across the entire concentric phase and is therefore less sensitive to brief spikes or fluctuations in signal processing. Peak velocity, by definition, depends on a very short portion of the movement and is more susceptible to differences in sampling rate, filtering, smoothing, and the internal algorithms used by each device (Pérez-Castilla *et al.*, 2019; Thompson *et al.*, 2020; Weakley *et al.*, 2021*b*; Ruiz-Alias *et al.*, 2024).

The exercise-specific nature of the findings is also worth highlighting. Agreement was generally stronger during the CHP than during the SHP. The SHP typically involves a wider grip and a bar path that may be slightly more variable than that of the CHP, especially as subjects accelerate the bar more aggressively at lighter loads (Suchomel *et al.*, 2015; Arauz *et al.*, 2026). This may magnify small device-related differences in tether angle and instantaneous peak detection (Fritschi *et al.*, 2021). In the present study, both devices were mounted on opposite ends of the barbell, which likely improved ecological validity but may also have introduced measurement differences related to side-specific or attachment-point-related bar movement (Fritschi *et al.*, 2021).

The present findings are broadly consistent with previous literature showing that device agreement is both exercise- and variable-dependent. Pérez-Castilla et al. reported that commercially available devices can differ meaningfully, even when overall validity is acceptable in traditional resistance exercises (Pérez-Castilla *et al.*, 2019). Weakley et al. later reinforced the broader point that commercially available monitoring devices should be evaluated individually rather than treated as interchangeable (Weakley *et al.*, 2021*b*). In exercises more similar to the current study, Suchomel et al. showed that the Tendo demonstrated acceptable validity and small practical differences relative to GymAware during the jump shrug and hang high pull (Suchomel *et al.*, 2023). Taken together, these findings support the interpretation that the Tendo is a reasonable field-based comparator and that the current SHP peak velocity differences likely reflect meaningful between-device differences rather than simple random noise.

The Vitruve-specific literature also helps contextualize the present results. González-Galán et al. reported promising concordance for the Vitruve in the bench press and full squat when compared with T-Force, whereas Ruiz-Alias et al. showed that validity of the Vitruve relative to GymAware was mixed and depended on the exercise mode and the variable being analyzed (González-Galán *et al.*, 2024; Ruiz-Alias *et al.*, 2024). Our data fit well within that emerging picture. Vitruve appears capable of producing useful velocity outputs in applied settings, but its level of agreement with other systems is not uniform across all tasks and variables. In our study, mean velocity remained highly comparable, whereas peak velocity in the faster SHP conditions showed larger discrepancies.

Another point worth emphasizing is that the present Bland–Altman regressions did not support a broad claim of proportional bias across all conditions. In fact, proportional bias was only evident for SHP mean velocity at 50% and 70% 1RM, and even there, the absolute mean differences between devices were very small. This suggests that the statistically significant slopes in those panels should be interpreted cautiously. By contrast, the SHP peak velocity plots showed consistent negative bias without significant proportional bias, indicating that the problem may be less about the bias increasing across the range and more about Vitruve systematically reading lower than Tendo. From an applied perspective, when using CHP and SHP for VBT, mean velocity appears to be the safer metric for between-device comparison. Practitioners who rely on peak velocity, especially at lighter loads, should avoid switching between devices within the same monitoring system or across different athlete profiles. If peak velocity thresholds are used to guide decision-making, they should remain device specific.

Several limitations should be acknowledged. First, the study compared Vitruve against Tendo, which is an established field device but not a criterion method such as 3D motion capture or a reference LPT like GymAware (Thompson *et al.*, 2020; Suchomel *et al.*, 2023). Therefore, the findings should be interpreted as agreement between devices rather than as criterion validity. Second, the present analyses do not establish intra-device or between-day reliability. Third, the sample was modest and limited to Division III athletes from basketball and hockey, which may limit generalizability. Fourth, only submaximal loads from 50–80% 1RM were examined.

Finally, the fixed device placement at opposite bar ends may have contributed to some of the observed differences, particularly under faster SHP conditions.

5. Conclusion

Vitruve and Tendo produced comparable mean velocity values during the clean and snatch high pull across submaximal loads in collegiate athletes. Peak velocity agreement was weaker, particularly during the snatch high pull, where Vitruve recorded lower peak velocities than Tendo at the lighter loads. Accordingly, mean velocity appears to be the more stable and defensible metric when comparing these devices during Olympic-derived pulling exercises. When peak velocity is of primary interest, the two systems should not be assumed to be interchangeable without caution.

Acknowledgements

The authors thank the Aurora University strength and conditioning staff for their significant collaborative efforts with data collection and the Aurora University men's and women's basketball and hockey teams for their willingness to work with our research team. Lastly, the authors acknowledge the Aurora University students enrolled in *EXS 3600* during the spring 2024 semester for their assistance with data collection.

Disclosures

No conflicts of interest, financial or otherwise, are declared by the authors.

Author Contributions

E.P., J.R.S., V.L.R., M.R.M., J.T.L., I.J.L., M.A., L.M.B., A.S., E.R., T.A.R., J.M.R., C.A.E., and M.D.B. conceived and designed the research; E.P., J.R.S., V.L.R., M.R.M., J.T.L., I.J.L., M.A., L.M.B., A.S., E.R., T.A.R., J.M.R., and M.D.B. collected data; E.P. and M.D.B. analyzed data; E.P. and M.D.B. interpreted the results of the tests; E.P. and M.D.B. prepared figures; E.P. and M.D.B. drafted the manuscript; E.P., C.A.E., and M.D.B. edited and revised the manuscript; E.P., J.R.S., V.L.R., M.R.M., J.T.L., I.J.L., M.A., L.M.B., A.S., E.R., T.A.R., J.M.R., C.A.E., and M.D.B. approved the final version of the manuscript.

References

[1]. Arauz PG, Garcia G, Llerena J & Kao I (2026). Biomechanical and neuromuscular differences between the snatch and clean in elite weightlifters. *Journal of Biomechanics* **195,** 113106.
[2]. Callaghan DE, Guy JH, Elsworthy N & Kean C (2022). Validity of the PUSH band 2.0 and Speed4lifts to measure velocity during upper and lower body free-weight resistance exercises. *Journal of Sports Sciences* **40,** 968–975.
[3]. Fritschi R, Seiler J & Gross M (2021). Validity and Effects of Placement of Velocity-Based Training Devices. *Sports* **9,** 123.
[4]. Gonzalez AM, Mangine GT, Spitz RW, Ghigiarelli JJ & Sell KM (2019). Agreement between the Open Barbell and Tendo Linear Position Transducers for Monitoring Barbell Velocity during Resistance Exercise. *Sports (Basel)* **7,** 125.
[5]. González-Badillo JJ, Marques MC & Sánchez-Medina L (2011). The importance of movement velocity as a measure to control resistance training intensity. *J Hum Kinet* **29A,** 15–19.
[6]. González-Badillo JJ & Sánchez-Medina L (2010). Movement Velocity as a Measure of Loading Intensity in Resistance Training. *Int J Sports Med* **31,** 347–352.

[7]. González-Galán J, Herrera-Bermudo JC, González-Badillo JJ & Rodríguez-Rosell D (2024). Validity and Concordance of a Linear Position Transducer (Vitruve) for Measuring Movement Velocity during Resistance Training. *Sensors (Basel)* **24,** 6444.

[8]. Jukic I, Castilla AP, Ramos AG, Van Hooren B, McGuigan MR & Helms ER (2023). The Acute and Chronic Effects of Implementing Velocity Loss Thresholds During Resistance Training: A Systematic Review, Meta-Analysis, and Critical Evaluation of the Literature. *Sports Med* **53,** 177–214.

[9]. Kilgallon J, Cushion E, Joffe S & Tallent J (2025). Reliability and validity of velocity measures and regression methods to predict maximal strength ability in the back-squat using a novel linear position transducer. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology* **239,** 335–348.

[10]. Moreno-Villanueva A, Pino-Ortega J & Rico-González M (2024). Validity and reliability of linear position transducers and linear velocity transducers: a systematic review. *Sports Biomechanics* **23,** 1340–1369.

[11]. Muñoz De La Cruz V, Agudo-Ortega A, Sorgente V, Turner AP & González-Ravé JM (2023). The effectiveness of adjusting resistance training loads through velocity-based techniques in experienced sprinters: a case series study. *Front Physiol* **14,** 1241459.

[12]. Pérez-Castilla A, Piepoli A, Delgado-García G, Garrido-Blanca G & García-Ramos A (2019). Reliability and Concurrent Validity of Seven Commercially Available Devices for the Assessment of Movement Velocity at Different Intensities During the Bench Press. *Journal of Strength and Conditioning Research* **33,** 1258–1265.

[13]. Ruiz-Alias SA, Şentürk D, Akyildiz Z, Çetin O, Kaya S, Pérez-Castilla A & Jukic I (2024). Validity and reliability of velocity and power measures provided by the Vitruve linear position transducer ed. Janicijevic D. *PLoS ONE* **19,** e0312348.

[14]. Suchomel TJ, Comfort P & Stone MH (2015). Weightlifting Pulling Derivatives: Rationale for Implementation and Application. *Sports Med* **45,** 823–839.

[15]. Suchomel TJ & Sole CJ (2017). Power-Time Curve Comparison between Weightlifting Derivatives. *J Sports Sci Med* **16,** 407–413.

[16]. Suchomel TJ, Techmanski BS, Kissick CR & Comfort P (2023). Reliability, Validity, and Comparison of Barbell Velocity Measurement Devices during the Jump Shrug and Hang High Pull. *JFMK* **8,** 35.

[17]. Thompson SW, Rogerson D, Dorrell HF, Ruddock A & Barnes A (2020). The Reliability and Validity of Current Technologies for Measuring Barbell Velocity in the Free-Weight Back Squat and Power Clean. *Sports* **8,** 94.

[18]. Vernon A, Joyce C & Banyard HG (2020). Readiness to train: Return to baseline strength and velocity following strength or power training. *International Journal of Sports Science & Coaching* **15,** 204–211.

[19]. Weakley J, Mann B, Banyard H, McLaren S, Scott T & Garcia-Ramos A (2021*a*). Velocity-Based Training: From Theory to Application. *Strength & Conditioning Journal* **43,** 31–49.

[20]. Weakley J, Morrison M, García-Ramos A, Johnston R, James L & Cole MH (2021*b*). The Validity and Reliability of Commercially Available Resistance Training Monitoring Devices: A Systematic Review. *Sports Med* **51,** 443–502.