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Stability of Load-Velocity Relationship in Bench Press Among Male College Students

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Abstract. In recent years, velocity-based training(VBT) has garnered growing attention as a novel method due to its ability of track training loads with greater precision and effective training outcomes assessment. The central mechanism of VBT relies on velocity data recorded during movement to assess, adjust and control the training load. 68 male college athletes from the seven sports were chosen as the subjects of this study. After 12 weeks of a strong-training plan, it was hoped that changes would occur in the Load-Velocity relationship of the bench press before and after the program. A German Eonde Pro device was employed to measure the speed of the barbell. Equations for the linear regression of MV, MPV and PV were developed in Origin2024. To compare the above indices for people at different levels of strength, SPSS was employed. Analysis of the speed of different loads for barbells shows that MV, MPV, PV and load are negatively correlated, and no significant differences in movement speed were found among the sports. After 12 weeks of strengthening exercises, the upper-body strength of all 68 people increased substantially; however, the mean values of MV, MPV and PV were not very different. ANOVA was employed to compare the means of MV, MPV, and PV among the seven sports; that is to say, no single sport consistently outperformed the others in all three velocity indicators. The stability of the load-velocity relationship for the bench press in different sports, strength levels and after organised strength training were all verified in the study. The above results can provide a scientific basis for the construction of strength training programs for athletes of various sports.

Keywords: Load-velocity relationship stability, Bench press, Male college students

1. Introduction

The role of strengthening the body to enhance athletic performance is well-known; it is believed that strengthening can help people perform better and reduce the risk of injuries [1, 2], and it is also one of the basic methods for maintaining good health and avoiding or managing chronic diseases in the general population [3, 4]. Strength training is often performed in the form of percentage-based training (PBT), and the intensity of this training varies according to different percentages of one-repetition maximum (1RM). However, the real-time effectiveness of PBT is limited, and too many one-repetition maximum (1RM) tests may increase the risk of injury [5]. With the development of technology, we are now able to measure the results of physical exercise and use these new ways to

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help us learn [6]. Velocity-based training (VBT) is one such new idea that has begun to attract more attention recently because it can measure the training load of athletes more accurately and provide an effective way to assess training results [7, 8]. The core mechanism of VBT is to determine how fast a player is moving and then adjust the training load for them in real time.

At the end of the 20th century, Chen S et al. used a self-developed motion velocity device to collect movement velocity data and quantified the intensity of strength training load. They found that this method was more effective for enhancing the speed strength of the subjects than the traditional %1RM approach [9-11]. In 2010, González B et al. were able to use a wire-based velocity measuring device (T-FORCE) and it was found that the mean velocity (MV) could be used to quantify the standard strength training loads [12]. Since then, VBT has attracted considerable attention in research and practice of strength training worldwide and has gradually beconing a key component of digital physical training [13]; it is now regarded as a method for training and a monitoring tool [14]. Compared with the traditional methods of calculating strength as a percentage of maximum strength (%1RM) or maximum repetitions (RM), VBT can also show how hard one's workout is at any moment by determining speed; there is a strong relationship between movement velocity and %1RM. VBT requires to be performed at high speeds to reduce physical fatigue by reducing the speed of movement and thus maintaining a certain level of training intensity [15], and the training intensity should match the goals [16]. Zhang X has carried out a meta-analysis of controlled experiments and found that VBT can improve the maximum strength, strength endurance, jumping and sprinting ability of trainees' lower limbs [17]. In Juan's study, VBT increased the absolute and relative power output of 19 soccer players during the concentric phase of half-squats. Based on the comparison experiment of swimming students, VBT has shown good results in improving the sports performance of these students over PBT [18]. After 7 weeks of VBT and PBT training, the squat 1RM, countermovement jump (CMJ) height and reactive strength index of rugby players have all increased [19]. Another study has explored the direct effects of VBT and PBT on deadlifts, and it was found that at the same load, force and work, VBT was higher than that of traditional percentage-based resistance training in terms of speed and increased power output [20].

Furthermore, VBT can also be employed to investigate how movement speed is affected by different loads, take advantage of the strong correlations among speed, %1RM, repetitions and fatigue [21, 22], and thus assist in the design, monitoring and adjustment of training plans [23]. VBT devices are usually trained on the training data, and then linear regression is employed to obtain the load-velocity relationship curve. These curves are used to estimate relative intensity (%1RM) and 1RM values [24, 25], and thus provide a basis for resistance training [26]. However, It is unknown whether speed-training affects the stability of speed. Some studies have shown that regular strength training can change the load-velocity relationship, but other research has not found an increase in MV, MPV or PV. The effect of strength level on the load-velocity relationship is also not clear. Some of the results show that there is an effect; whereas others do not. The Load-velocity relationship of exercises includes bench press [27, 28], deadlift [29] and squat. Nonetheless, most existing studies focus on single-sport training groups, which limits the generalizability of their findings. This study not only investigates how strength level affects the load-velocity relationship but also incorporates athletes from multiple sports for a broader comparative analysis. By addressing the limitations of single-sport samples, this study aims to provide a scientific foundation for shaping strength training protocols for cross-sport athletes, analyzing the effects of strength level and systematic strength training on the load-velocity relationship.

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2. Materials and methods

2.1. Participants

The participants were male college athletes from seven sports disciplines (athletics, basketball, football, badminton, volleyball, Kung fu, and rock climbing) at Zhengzhou Health College, aged between 19 and 20 years. The inclusion criteria were: (1) at least one year of systematic training experience in their respective sport; (2) familiarity with bench press exercises and the ability to perform them with proper technique; (3) no history of shoulder, elbow, or other upper limb injuries within the past six months; (4) voluntary participation with signed informed consent. All participants provided informed consent voluntarily. Participant details, including height, weight, age, and group size, are provided in Table 1.

Table 1. Participant parameters by sport

Serial Number	Sport	Height (cm)	Weight (kg)	Age (years)	Participants
1	Athletics	176.7±5.66	66.8±10.28	20.4±1.08	12
2	Basketball	179.2±5.87	70.8±8.35	19.6±0.70	10
3	Football	176.6±2.41	68.1±7.91	19.8±1.03	10
4	Badminton	180.1±6.07	76.7±7.87	20±0.81	7
5	Volleyball	179.8±5.79	75.5±8.8	20.2±1.03	10
6	Kung fu	175.8±4.8	70.2±4.32	19.4±0.84	10
7	Rock Climbing	176.9±6.75	61.3±9.95	20±0.87	9

2.2. Participants experimental equipment

A German Eonde Pro smart tracker strength training assessment sensor, paired with a mobile application, was used for barbell velocity measurement. The device has demonstrated high accuracy and repeatability [30]. To ensure reliable data collection, the VBT device continuously monitored the entire training process, capturing the following indicators:

Table 2. Explanation of various speed indicators

Serial Number	Speed Indicators	Explanation
1	Mean Velocity (MV)	The average velocity during the barbell press.
2	Peak Velocity (PV)	The highest velocity reached during the barbell press.
3	Mean Propulsive Velocity (MPV)	The average velocity during the acceleration phase of the barbell press, where acceleration exceeds gravitational acceleration.
4	Average Mean Velocity (MV-avg)	The average of MV values measured from 30% to 100% 1RM in 10% increments.
5	Average Mean Propulsive Velocity (MPV-avg)	The average of MPV values measured from 30% to 100% 1RM in 10% increments.
6	Average Peak Velocity (PV-avg)	The average of PV values measured from 30% to 100% 1RM in 10% increments.
7	Mean Velocity at 1RM (MV-1RM)	The MV recorded when lifting a weight that can be performed only once with proper form.

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Table 2. (continued)

8	Mean Propulsive Velocity at 1RM (MPV-1RM)	The MPV recorded under the same 1RM condition.
9	Peak Velocity at 1RM (PV-1RM)	The PV achieved during a single proper lift at 1RM.

The bench press rack used met international bench press training standards, with specifications as follows: dimensions of 1700 × 1500 × 1930 mm, pipe fittings measuring 70 × 50mm, a barbell load-bearing capacity of 400kg, and an approximate weight of 45kg.

2.3. Experimental steps

After the participants were introduced to the bench press and resistance training protocol, they were given at least three days of rest to allow their bodies to baseline to their normal state before the next test session [31]. Due to being unfamiliar with the test, a short introductory course was organised for the students to learn about it beforehand.

Gradually increase the weight in the bench press test until the participant achieved their one-repetition maximum (1RM) [32, 33]. The start of the test was at a mass of 20 kg, and then 10 kg was added one by one until the average propulsive velocity (MPV) reached 0.5 m/s. After this point, the weight was increased by 2.5kg in steps until the 1RM was reached. To reduce the negative impact of fatigue on performance, the rest periods for loads at or below 80% of 1RM was set to 3 minutes, and for loads exceeding 80% of 1RM, it was increased to 5 minutes so that the body has had sufficient recovery time between sets.

A typical bench press stand from the collection was chosen to ensure its regularity and stability. The person lies on their back, lightly rests the shoulder blades on the mat, keeps both feet flat and separated about the width of the shoulders. The Barbell was set to eye level for an even start. Hold the barbell, bring it down to your chest, then pull it up with all your strength in as short a time as possible to show your explosive power. Testing was carried out at 30% and 35% of the 1RM, and then increased by 5% each time up to the 1RM. At each load, the participants were to push the barbell as fast as they could. Carry out the three load runs and select the one with a faster speed and correct form for analysis from among them.

Prior to the intervention, all participants of the training group had completed full-body physical examinations and determined their 1RM through incremental loading. One week later, several more experiments were carried out to measure the speed of the barbell at various weights. Among the types of training, strength levels and training conditions were compared to find the reasons for changes in the stability of the load-velocity relationship. Following the initial tests, all the people participated in a special 12-week training program every Tuesday at 4:00 PM for two hours each time. Training programmes have been introduced to strengthen the chest, abdomen and upper body. After the training period, progressive load tests were carried out to see whether there had been any changes in athletic performance over time due to training (Figure 1).

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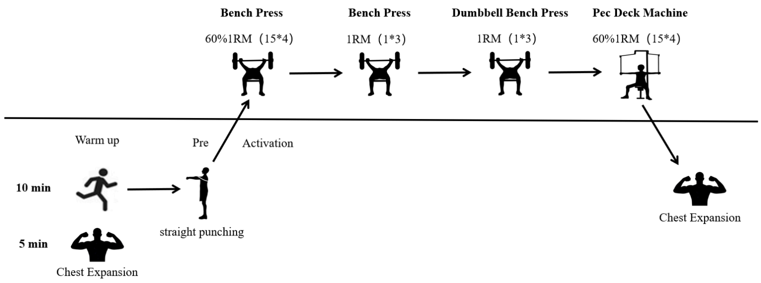

Figure 1. Training process demonstration

2.4. Data analysis

The MV, MPV and PV values at various loads of the VBT equipment were recorded before and after training. Equations for MV, MPV and PV are linear regressions in Origin 2024. To compare the differences in these indicators among people of different strengths and to compute Cohen's d, SPSS software was used for the analysis. Comparisons were carried out among the sports disciplines for eta squared (η^2) and statistical power. After completing the 12 weeks of strength training program, it was decided whether the increase in strength had changed the load-velocity relationship by repeating the test.

3. Results

3.1. Negative correlation and consistency of barbell velocity indicators under different loads

Analysis of barbell velocity at different percentages of 1RM load shows that MV, MPV and PV are all negatively correlated with load. Figure 2 shows the above. Figure 2-A shows the change of MV with load. Figure 2-B is the relationship between MPV and load. Figure 2-C is the relationship between PV and Load. Based on the above analysis, it can be concluded that MV, MPV, PV and load are all strongly negatively correlated with each other (MV: $R^2 = 0.83$, $p < 0.001$; MPV: $R^2 = 0.83$, $p < 0.001$; PV: $R^2 = 0.87$, $p < 0.001$). According to the data, velocity gradually decreases as load increases, and all velocity indices follow the same pattern. The rate of decline was different among the three speed indices (MV, MPV and PV), but all fell with an increase in load.

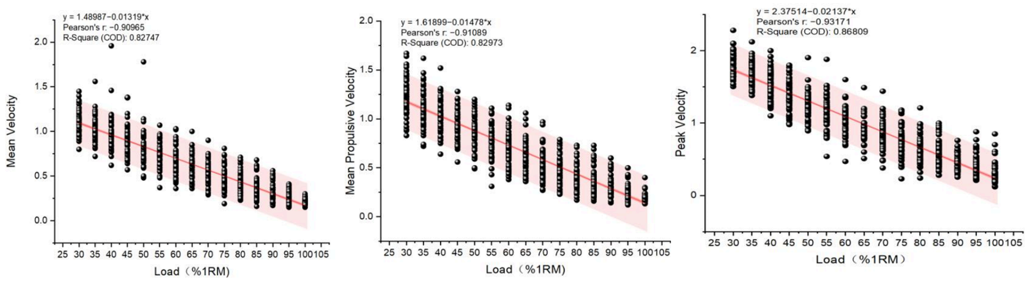

Figure 2 - A Changes in MV with Varying Loads

Figure 2 - B Relationship between MPV and load

Figure 2 - C Association between PV and load

Figure 2. Load-velocity relationship for different velocity indicators

At varying loads, MV, MPV and PV show good agreement, so they may be used jointly as mutual predictors. Little has been done in previous research on the load-velocity relationship of various speed indicators. The three speed indicators in this study are highly correlated ($R^2 > 0.8$), so we will further explore how they are related in the load-speed model.

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3.2. The change patterns of speed indicators at different relative intensities and the load-velocity relationship

An increase of 5% was used for the increment, and the changes in MV, MPV and PV at various relative intensities are shown in Table 3. As %1RM increased, the values of MV, MPV and PV all decreased consistently. An increase of 5 percent in the load intensity will result in a decrease of approximately -0.066 for MV, -0.074 for MPV and -0.111 for PV. Therefore, it can be concluded that the load is negatively correlated with barbell speed.

Table 3. Relationship between MV, MPV, and PV at different relative intensities

%1Rm	MV	Upper - Lower	MPV	Upper - Lower	PV	Upper - Lower
30%	1.13±0.15	1.09-1.16	1.24±0.19	1.2-1.29	1.87±0.15	1.83-1.9
35%	1.05±0.14	1.02-1.09	1.13±0.17	1.09-1.17	1.69±0.15	1.65-1.72
40%	0.98±0.18	0.93-1.02	1.03±0.16	0.99-1.07	1.54±0.2	1.49-1.59
45%	0.89±0.14	0.86-0.93	0.95±0.14	0.91-0.98	1.37±0.21	1.32-1.42
50%	0.82±0.18	0.78-0.87	0.87±0.16	0.83-0.9	1.27±0.16	1.23-1.31
55%	0.74±0.14	0.7-0.77	0.77±0.16	0.74-0.81	1.14±0.22	1.09-1.19
60%	0.68±0.15	0.65-0.72	0.71±0.17	0.67-0.75	1.03±0.18	0.98-1.07
65%	0.6±0.12	0.57-0.63	0.62±0.16	0.59-0.66	0.93±0.16	0.89-0.96
70%	0.54±0.12	0.51-0.57	0.56±0.15	0.52-0.59	0.82±0.19	0.78-0.87
75%	0.47±0.12	0.45-0.5	0.48±0.13	0.45-0.51	0.74±0.18	0.7-0.79
80%	0.41±0.12	0.38-0.44	0.4±0.13	0.37-0.43	0.63±0.18	0.59-0.67
85%	0.37±0.12	0.34-0.4	0.36±0.13	0.33-0.39	0.57±0.17	0.53-0.62
90%	0.31±0.09	0.29-0.33	0.3±0.1	0.28-0.33	0.47±0.11	0.44-0.5
95%	0.26±0.06	0.25-0.28	0.25±0.08	0.23-0.27	0.41±0.14	0.37-0.44
100%	0.21±0.03	0.21-0.22	0.2±0.04	0.19-0.21	0.32±0.12	0.29-0.35
Mean	0.63±0.1	0.61-0.66	0.66±0.11	0.63-0.69	0.99±0.1	0.96-1.01

The trend of speed in this study is consistent with that reported in the previous study [34], and there are no significant differences in the speed of various sports. The consistency of this will provide theoretical support for the application of velocity-based training across multiple sports disciplines.

3.3. Relationship between strength level and velocity indicators

The relative strength ratio (RSR) is defined as the 1RM weight lifted divided by body mass, and then participants were ranked by their RSR. Those with relatively higher RSR values were in Group 1 (G1), and those with relatively lower RSR values were in Group 2 (G2). As shown in Table 4, the relative strength of athletes in G1 was significantly higher than that of athletes in G2. However, there were no significant differences in MV, MPV, PV or their corresponding 1RM values among the groups. Therefore, it can be concluded that the difference in relative strength did not affect the velocity index of the bench press. Analysis of the Cohen's d values for G1 and G2 showed that all the differences in velocity indicators were less than 0.12, both in the 1RM condition and in the

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average of loads. These results clearly indicate that relative strength had minimal to no impact on barbell velocity.

Table 4. Differences in the three velocity indicators at different strength levels

Category	RSR	MV-avg	MPV-avg	PV-avg	MV-1rm	MPV-1rm	PV-1rm
G1	1.12±0.09*	0.62±0.09	0.66±0.11	0.98±0.08	0.21±0.03	0.2±0.03	0.32±0.12
G2	0.85±0.09*	0.63±0.10	0.66±0.12	0.99±0.11	0.21±0.03	0.2±0.04	0.33±0.12
Cohen's d	-3	0.11	0	0.10	0	0	0.08

The relationship between strength level and velocity remains controversial. Based on testing and data from athletes across seven sport-specific training teams in this study, no significant effect of relative strength on the three bench press velocity indicators (MV, MPV, PV) was observed. Furthermore, no prior research has validated these three velocity (MV, MPV, PV) indicators using multi-sport training teams as subjects, making this study a novel contribution to the field.

3.4. Impact of strength training on velocity indicators

As presented in Table 5, after 12 weeks of strength training, the 68 participants were retested. Maximum strength increased significantly, from 67.87 ± 10.49 pre-training to 75.44 ± 11.65 post-training ($p < 0.01$). In contrast, the mean values of MV, MPV, and PV exhibited only minor changes. Cohen's d values ranged from -0.05 to 0.05, and Effect Size® values fell between 0.02 and 0.03, all close to zero. These results suggest that changes in the three velocity indicators (MV, MPV, PV) were negligible. Statistical power values remained close to 0.05, and the low Cohen's d and Effect Size® values further support the conclusion that pre- and post-training differences were minimal.

Table 5 Differences in velocity indicators before and after strength training

Table 5. - A MV indicators before and after strength training

MV(%1Rm)	Pre-training	Post-training	Cohen's d	Effect Size(r)	Power
30%	1.13±0.15	1.13±0.15	0.02	0.01	0.05
35%	1.1±0.14	1.05±0.15	0.01	0.01	0.05
40%	0.98±0.18	0.97±0.18	0.02	0.01	0.05
45%	0.89±0.14	0.90±0.14	-0.04	-0.02	0.06
50%	0.82±0.18	0.83±0.18	-0.01	0.00	0.05
55%	0.74±0.14	0.74±0.13	-0.02	-0.01	0.05
60%	0.68±0.15	0.68±0.15	-0.02	-0.01	0.05
65%	0.60±0.12	0.60±0.13	0.00	0.00	0.05
70%	0.54±0.12	0.54±0.12	0.02	0.01	0.05
75%	0.47±0.12	0.47±0.12	0.02	0.01	0.05
80%	0.41±0.12	0.41±0.11	-0.03	-0.01	0.05
85%	0.37±0.12	0.37±0.12	0.02	0.01	0.05
90%	0.31±0.09	0.31±0.09	0.00	0.00	0.05
95%	0.26±0.06	0.26±0.06	0.01	0.00	0.05

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Table 5. (continued)

100%	0.21±0.03	0.21±0.03	0.00	0.00	0.05
Mean	0.63±0.10	0.63±0.10	-0.01	0.00	0.05

Table 5. - B MPV indicators before and after strength training

MPV(%1Rm)	Pre-training	Post-training	Cohen's d	Effect Size(r)	Power
30%	1.24±0.19	1.24±0.19	0.01	0.01	0.05
35%	1.13±0.17	1.13±0.17	0.00	0.00	0.05
40%	1.03±0.16	1.03±0.16	-0.01	-0.01	0.05
45%	0.95±0.14	0.95±0.14	-0.01	0.00	0.05
50%	0.87±0.16	0.87±0.15	-0.04	-0.02	0.06
55%	0.77±0.16	0.77±0.16	0.02	0.01	0.05
60%	0.71±0.17	0.71±0.16	0.01	0.00	0.05
65%	0.62±0.16	0.62±0.16	0.01	0.01	0.05
70%	0.56±0.15	0.55±0.16	0.01	0.00	0.05
75%	0.48±0.13	0.48±0.13	-0.02	-0.01	0.05
80%	0.40±0.13	0.40±0.13	-0.01	0.00	0.05
85%	0.36±0.13	0.36±0.13	0.00	0.00	0.05
90%	0.30±0.10	0.30±0.10	0.00	0.00	0.05
95%	0.25±0.08	0.25±0.08	0.03	0.01	0.05
100%	0.20±0.04	0.20±0.04	-0.02	-0.01	0.05
Mean	0.66±0.11	0.66±0.11	-0.01	-0.01	0.05

Table 5. - C PV indicators before and after strength training

PV(%1Rm)	Pre-training	Post-training	Cohen's d	Effect Size	Power
%30PV	1.87±0.15	1.86±0.15	0.03	0.02	0.05
%35PV	1.69±0.15	1.69±0.15	-0.03	-0.02	0.05
%40PV	1.54±0.20	1.54±0.20	0.01	0.00	0.05
%45PV	1.37±0.21	1.37±0.21	-0.01	-0.01	0.05
%50PV	1.27±0.16	1.26±0.16	0.03	0.02	0.05
%55PV	1.14±0.22	1.14±0.22	0.00	0.00	0.05
%60PV	1.03±0.18	1.03±0.19	-0.01	-0.01	0.05
%65PV	0.93±0.16	0.92±0.16	0.02	0.01	0.05
%70PV	0.82±0.19	0.82±0.19	0.02	0.01	0.05
%75PV	0.74±0.18	0.75±0.18	-0.01	-0.01	0.05
%80PV	0.63±0.18	0.63±0.18	-0.02	-0.01	0.05
%85PV	0.57±0.17	0.57±0.17	0.00	0.00	0.05
%90PV	0.47±0.11	0.47±0.11	-0.01	0.00	0.05
%95PV	0.41±0.14	0.41±0.14	-0.01	-0.01	0.05

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Table 6. (continued)

%100PV	0.32±0.12	0.32±0.12	0.00	0.00	0.05
Mean	0.99±0.10	0.98±0.10	0.04	0.02	0.06

In this study, seven groups of athletes from the different training teams took part in the 12-week strength training programme. Although there was a relatively significant increase in strength ($p < 0.05$), MV, MPV and PV did not change significantly after training compared to before. Most previous studies have focused only on MPV or %1RM in the velocity index. By incorporating MV, MPV and PV to this work, we hope to offer a broader view of their connections with load and help lay the theoretical foundation for designing training plans for athletes in various sports.

3.5. Impact of different sports on the three velocity indicators

Table 6 shows the meanvalues, standard deviation, effect size and statistical power of the three velocity indicators for the different sports. Analysis of variance (ANOVA) was used to determine if there were differences in MV, MPV and PV among the seven sports. The results showed some differences among the sports. Badminton players had the highest MV and MPV; volleyball players were second, and athletics, football, and basketball players all had the same MV and MPV. The results of PV were the same for all the sports and did not differ significantly. No single sport had been leading in all three speed indices consistently.

Table 6. Analysis of differences in the three velocity indicators among different sports

Category	Sports	Number	Average Value	Standard deviation	η2	Power
MV	Athletics	12	0.63	0.08	0.05	0.20
	Basketball	10	0.62	0.09		
	Football	10	0.61	0.10		
	Badminton	7	0.68	0.13		
	Volleyball	10	0.65	0.13		
	Kung fu	10	0.61	0.06		
	Rock Climbing	9	0.65	0.11		
MPV	Athletics	12	0.66	0.09	0.05	0.18
	Basketball	10	0.63	0.11		
	Football	10	0.63	0.11		
	Badminton	7	0.70	0.14		
	Volleyball	10	0.68	0.15		
	Kung fu	10	0.65	0.09		
	Rock Climbing	9	0.68	0.12		
PV	Athletics	12	0.98	0.08	0.03	0.14
	Basketball	10	0.97	0.12		
	Football	10	0.97	0.10		
	Badminton	7	1.00	0.13		
	Volleyball	10	0.98	0.14		
	Kung fu	10	0.98	0.07		

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Table 6. (continued)

PV	Rock Climbing	1.03	0.07	0.07	0.03	0.14

The size of effect for all velocity indicators was low. Eta squared (η2) was used to estimate the effect of sport on MV, MPV and PV, and the statistical power is the probability of correctly rejecting the null hypothesis. All η2 values were less than 0.1, and the statistical power values were less than 0.2; thus, there were little differences in velocity among sports. Based on the above results, the three velocity indicators are not significantly different among athletes in different sports. It offers a basis for the construction of strength training programmes across all kinds of sports and helps to form standardized training protocols.

4. Discussion

This study investigated the relationship between relative load and three velocity indicators (MV, MPV, and PV) in athletes from various sports. The derived linear regression equations are consistent and stable in sports, at different levels of strength, and at various stages of training; standardised strength training programmes can be developed to across sports.

Seven different training teams took part in this study, and it was found that the linear regression equations for MV, MPV and PV were consistent and stable across different sports, different levels of strength and training interventions. Therefore, it can be concluded that a single-protocol strength training system is feasible for across sports.' The results are in line with the previous studies [35]. For every 5% increase in %1RM, the corresponding reduction in MV, MPV and PV was about -0.066, -0.074 and -0.111, respectively. These figures are in line with the previous results; thus, the velocity indicators of different sports are not significantly different.

Although the relationship between strength level and movement velocity has not been firmly established in recent years [36], as shown by the many data analyses in this paper, it is not obvious that changes in strength will alter MV, MPV, or PV during a bench press. Although there was a clear difference in RSR values between the two groups, no significant differences were found in the velocity indicator at 1RM or in their average values. These results suggest a weak or nonexistent association between strength level and movement velocity, consistent with previous findings [37]. The similar conclusions have been reached in the studies of squats and pull-ups; thus, it is also suggested that these velocity indicators are more closely associated with %1RM than with athletes sport disciplines [38, 39].

After 12 weeks of strength training, all the participants had shown some improvement in their bench press performance compared with before training. However, Cohen's d values for MV, MPV and PV were between -0.05 and 0.05, and the effect sizes were between 0.02 and 0.03. This is in line with previous research that has shown little difference in velocity indicators before and after training, all less than 0.03 [12]. The power of the test is still about 0.05, so although the effect is stronger, it has not changed. The relationship between the increase in strength and changes in velocity indicators is not clear. Some studies have indicated that free weights are subject to many outside factors and thus lack uniformity [40]. However, according to the results of this study, even after being trained with free weights, the load-velocity curve has not been changed. There was no significant difference in the means or standard deviations of the velocity indicators before and after the intervention, so it was concluded that there was a small effect size. Among the athletes from the seven different sports training teams, there were no significant changes in MV, MPV and PV after 12

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weeks of the strength programme. Therefore, although the strength has increased, the load-velocity relationship isremains stable [41].

Athletes from various sports were compared in this study, and MV, MPV, and PV remained stable in all of them. ANOVA results show that the effect size η^2 is ≤ 0.05 and the statistical power is ≤ 0.2, so it can be concluded that there is no significant difference in the three velocity indicators among sport groups [42]. Additionally, the mean values and standard deviations of MV, MPV, and PV across the different sports were also similar, indicating that they are stable regardless of the sport.

5. Practical applications

This study offers practical insights for coaches and athletes seeking to optimize bench press training across different sports. The strong negative correlation between load and velocity indicators (MV, MPV, PV) confirms that velocity-based training (VBT) can serve as a reliable method for real-time load assessment. Coaches may apply VBT to modulate training intensity dynamically, eliminating the need for frequent 1RM assessments. This strategy helps reduce injury risk and ensures optimal effort throughout each training set.

A key practical implication is the cross-sport applicability of VBT protocols. Despite variations in athletic backgrounds, the consistency of velocity-load relationships across seven sports (athletics, basketball, football, etc.) suggests standardized VBT curves can be broadly applied. For instance, coaches can use the observed average velocity decreases to prescribe training zones tailored to specific performance objectives (e.g., hypertrophy, power, or maximal strength).

Velocity-based indicators remained stable following 12 weeks of strength training. These findings confirm that VBT remains applicable even after athletes gain substantial 1RM strength. This enables coaches to maintain consistent velocity thresholds for training prescription, thereby simplifying long-term program design. Moreover, relative strength level has only a minor influence on velocity indicators. This supports the application of VBT in group training, enabling athletes of varying abilities to train together using common velocity targets.

Ultimately, the absence of sport-specific effects on velocity outcomes indicates that VBT can be incorporated into general physical preparation phases for multi-sport athletes. Coaches can utilize this by designing sport-agnostic strength blocks focused on velocity-controlled parameters, followed by a transition to sport-specific periodization. This strategy balances efficiency with individualization, rendering VBT an essential component for contemporary strength and conditioning programs.

6. Limitation

The sample consisted of 68 male college athletes, all from sports training teams. The limited diversity in gender and age constraints the generalizability of the findings. Future studies should expand the sample size and include a broader range of sports. Additionally, incorporating participants of diverse genders and age groups would enhance the applicability and reliability of the findings.

7. Conclusion

The change in the load-velocity curve for the bench-press test of 68 male college students in the all-sports programme at German EondePro sensors is presented in this paper. According to the results, MV, MPV and PV are all negatively correlated with load intensity, but there is no significant difference in strength levels. After strengthening exercise for 12 weeks, the maximum strength had increased, but MV, MPV, and PV did not change. Although there was some variation in the load-velocity relationship among the sports, it was not statistically significant.

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