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VALIDITY AND RELIABILITY OF A MOBILE APPLICATION FOR VELOCITY-BASED TRAINING (VBT) IN THE BENCH PRESS EXERCISE

VALJANOST I POUZDANOST MOBILNE APLIKACIJE *METRIC VBT* ZA VELOCITY-BASED TRAINING U VJEŽBI POTISAK S RAVNE KLUPE

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ABSTRACT

The aim of this study was to determine the validity and reliability of *Metric VBT* mobile application during the bench press exercise. The research was attended by fifteen male participants (age 24.2 ± 1.6 years; height 183.8 ± 7.51 cm; weight 87.8 ± 8.5 kg) with experience in strength training and bench press exercise for at least two years. Participants were required to perform three maximally fast concentric repetitions at loads of 45%, 60% and 75% of 1RM in the bench press exercise. Movement velocity was simultaneously recorded using the *Vitruve* measuring device and the *Metric VBT* mobile application.

Results showed a statistically significant ($p < 0.05$), very strong correlations of the total number of repetitions for the variables of mean velocity (r = 0.93), peak velocity (r = 0.91) and strong correlations for range of motion (r = 0.75). Also, there was a statistically significant ($p < 0.05$) medium to very strong correlation for individual loads in the variables of mean velocity (r = 0,47 to 0,89), peak velocity (r = 0,79 to 0,81) and range of motion (r = 0,71 to 0,79). On the other side, reliability for individual repetitions measured by intraclass correlation coefficient (ICC) indicates in existence of statistically significant ($p < 0.05$) excellent reproducibility of results for mean velocity (ICC = 0,93 to 0,95), peak velocity (ICC = 0,89 to 0,97) and range of motion (ICC = 0,95 to 0,97). Variation of results within one subject for individual loads measured using the coefficient of variation (CV) indicates an acceptable level of variability (<10%) for mean velocity (CV = 3.91 to 7.09%), peak velocity (CV = 4.90% to 9.41%) and range of motion (CV = 3.07% to 3.91%). Ultimately, the obtained results support the use of the *Metric VBT* mobile application to track movement velocity in the bench press exercise.

Key words: validity, reliability, velocity – based training, VBT, bench press

SAŽETAK

Cilj ovog rada je bio utvrditi valjanost i pouzdanost mobilne aplikacije *Metric VBT* u vježbi potisak s ravne klupe. Istraživanju je pristupilo petnaest muških ispitanika (dob 24,2 ± 1,6 godina; visina 183,8 ± 7,51 cm; tjelesna masa 87,8 ± 8,5 kg) s iskustvom u treningu s opterećenjem te vježbi potisak s ravne klupe u trajanju od najmanje dvije godine. Od ispitanika se zahtijevalo izvođenje tri maksimalno brza koncentrična ponavljanja pri opterećenjima od 45%, 60% i 75% 1 RM-a u potisku s ravne klupe. Brzina pokreta mjerila se istovremeno pomoću *Vitruve* mjernog uređaja te mobilne aplikacije *Metric VBT*.

Rezultati su utvrdili statistički značajnu, odnosno vrlo jaku korelaciju za sva ponavljanja za varijable srednje (r = 0,93) i vršne brzine (r = 0,91) te visoku korelaciju amplitude pokreta (r = 0,75). Također, postoji statistički značajna srednja do vrlo jaka korelacija za pojedinačna opterećenja u varijablama srednje (r = 0,47 do 0,89) i vršne brzine (r = 0,79 do 0,81) te jaka korelacija amplitude pokreta (r = 0,71 do 0,79). S druge strane, pouzdanost za pojedinačna ponavljanja mjerena intraklasnim koeficijentom korelacije (ICC) ukazuje u postojanje statistički značajne ($p < 0,05$) izvrsne ponovljivosti rezultata za varijable srednje (ICC = 0,93 do 0,95) i vršne brzine (ICC = 0,89 do 0,97) te amplitude pokreta (ICC = 0,95 do 0,97). Varijacije rezultata unutar jednog ispitanika za pojedinačna opterećenja mjerene pomoću koeficijenta varijacije (CV) govore o prihvatljivoj razini varijabilnosti (<10%) za varijable srednje (CV = 3,91% do 7,09%) i vršne brzine (CV = 4,90% do 9,41%) te amplitude pokreta (CV = 3,07% do 3,91%). Zaključno, utvrđeni rezultati podržavaju uporabu mobilne aplikacije *Metric VBT* za praćenje brzine pokreta u vježbi potisak s ravne klupe.

Ključne riječi: valjanost, pouzdanost, velocity – based training, VBT, potisak s ravne klupe

INTRODUCTION

Resistance training represents the most common form of intervention in sports practice for the purpose of achieving various muscular adaptations (21). To satisfy the desired physiological responses, it is necessary to control various acute training variables in which the intensity represents the most important factor (3, 5). In practice, the most common form of determining load intensity is by determining the percentage of a previously estimated one repetition maximum (1RM) value or using the repetition zone. Given that research supports the high validity of this method, there is a problem of reliability due to periodic fluctuations in maximum strength that can be acute due to fatigue, and chronic due to adaptation to previous training stimuli (9). Also, research indicates inter-individual differences when it comes to defining repetition zones at different percentages of 1RM (18). These limitations encourage the search for more objective tools for monitoring training load, which leads to a method called Velocity-Based Training (VBT).

Weakley et al. (26) defined VBT as a method that uses movement velocity as a measurement variable to provide information and improve the training process. More simply, it refers to the use of various devices for measuring movement velocity in order to monitor the training response. Under conditions when the concentric part of the movement is performed with maximum possible effort, the relationship between movement velocity and external load becomes inversely proportional (27). Accordingly, with an increase in external load, the speed of concentric movement decreases (11). The decrease in movement velocity occurs until the person reaches a load of 1RM, where the movement velocity at the last repetition is defined as the minimal velocity threshold (MVT) (11). Also, there are clear inter-individual differences in MVT that need to be taken into account (17). Insights such as the inverse proportional relationship between force and velocity and the minimal velocity threshold for a particular exercise allow for the estimation of 1RM using submaximal loads, known in the literature as load-velocity profiling (12). Research indicates high accuracy of this method for estimating 1RM, where the strength of the relationship is most often measured using a simple linear regression equation in which the R^2 value usually ranges between 0.993 and 0.999 (9).

Research indicates great benefits of using VBT for monitoring fatigue, as well as the ability to provide real-time feedback which improves training impact (25). The reason for this premise lies in the physiological conditions of most sports that require activation of high threshold motor units and organization of fast-twitch type II muscle fibers that occur in conditions of low neuromuscular fatigue (19). For this reason, monitoring the variable of velocity loss (VL) of individual repetitions within and between sets represents the basis for objectively directing the desired adaptation (10). There are different velocity variables that are monitored and controlled through VBT, among which the most common is mean (average) velocity (MV) which encompasses the average velocity throughout the entire concentric part of the movement, and peak velocity (PV) as the highest velocity reached within the concentric part of the movement (26). Due to their high reliability, these variables are very common subjects of measurement in science and sports practice when it comes to resistance training (8). The gold standard in measuring the necessary kinematic parameters is a 3-dimensional system with cameras for velocity measurement (26). However, due to lower financial availability and non-portability, there was a need for smaller and more easily accessible measuring devices (18). Research indicates that linear position transducers (LPT) and accelerometers are the most commonly applied alternatives in science and sports practice (26).

Previous research has studied the metric characteristics of only a few mobile applications for VBT since there are only a few on the market, among which the most famous is the MyLift application (modification of PowerLift). Balsalobre-Fernández et al. (1) investigated the validity and reliability of the PowerLift mobile application in 10 highly trained Powerlifting competitors in estimating 1RM in the bench press exercise compared to an LPT device and concluded a very strong correlation ($r = 0.994$) between devices in the mean velocity variable. Also, statistically significant ($p < 0.05$) reliability was measured using the intraclass correlation coefficient ($ICC = 0.965$) between both devices, as well as a very strong correlation ($r = 0.98$) between actual and estimated 1RM values.

Perez-Castilla et al. (16) investigated the reliability of 7 commercially available VBT devices, including the MyLift application, for estimating 1RM in the bench press exercise on a Smith machine. The results showed that the mobile application was the third most reliable measuring device in the mean velocity variable with a coefficient of variation of 3.97% and a statistically significant very strong correlation ($r = 0.947$) compared to the "gold standard", as well as a statistically significant high intraclass correlation coefficient.

In recent years, a new iOS mobile application called Metric VBT (Core Advantage, Melbourne, Australia) has appeared. It is a mobile application that functions through a mobile camera system tracking various kinematic parameters with the help of artificial intelligence. Due to its relative novelty, there are not enough studies that have investigated and measured its important metric characteristics such as validity and various forms of reliability.

Tober et al. (24) conducted a pilot study (n=1) on the validity and reliability of the Metric VBT application compared to an optical camera system in squat, deadlift and bench press exercises All exercises were performed with 40 kg load in two sets of eight repetitions each. In the first set, the emphasis was on slow execution of the concentric part of the movement, while in the second set, the emphasis was placed on fast execution. The results showed a very strong correlation for range of motion ($r = 0.9862$) and mean velocity ($r = 0.9841$). Given that this was a pilot study, the researchers warned of the need to conduct additional scientific measurements to confirm current findings. This was done by Taber et al. (22) who repeated the protocol of the pilot study, however, this time nine subjects participated in the testing. The results of this study confirmed the findings from the initial work. The shortcomings of the conducted studies are reflected in the use of the same load for all subjects and in all exercises, given that there are clear inter-individual differences in %1RM. Also, the researchers used subjective determination of movement execution tempo.

Therefore, the aim of this study was to determine the metric characteristics of validity and reliability of the Metric VBT mobile application in the bench press exercise through a series of different loads expressed in % 1RM. Based on current knowledge, this is the first study that will investigate the metric characteristics of the mentioned measuring device through a wider range of loads, in order for the obtained results to gain practical significance.

SUBJECTS AND METHODS

Fifteen male subjects (age 24.2 ± 1.6 years; body height 183.8 ± 7.51 cm; body mass 87.8 ± 8.5 kg) with experience in resistance training and the bench press exercise for at least two (2) years voluntarily participated in the study. The criterion for including subjects was the absence of musculoskeletal and other health difficulties. Subjects were required not to practice any type of resistance training for at least 48 hours before testing. The number of subjects needed for the study was calculated using G*Power statistical power software (version 3.1) (effect size [ES] = 0.5; α = .05; power = 0.8). The Ethics Committee of the Faculty of Kinesiology, University of Zagreb issued approval for conducting the research and all subjects signed written consent to participate in the study (approval number: 67/2024).

The research was conducted on the Faculty of Kinesiology, University of Zagreb and lasted one day. Before conducting the actual testing, the 1RM value in the bench press exercise was verbally estimated among the subjects. The measurement was preceded by a ten-minute dynamic warm-up of the whole body with special emphasis on the shoulder girdle regions. Then, the entire research protocol was presented to the subjects and they were familiarized with the peculiarities of the VBT device operation. Subjects were required to perform 3 maximally fast concentric repetitions at loads of 30, 45, 60 and 75% of 1RM. Rests between loads were three (3) minutes. During the exercise, the Vitruve linear position transducer (alias Speed4Lift, Madrid, Spain) was attached to one end of the Olympic bar using a Velcro strap, while the mobile device camera was vertically attached to a tripod at a height and distance where it was possible to read the movement performance. After the repetitions were performed, the data was read and stored for statistical processing.

Measurement with the Metric VBT mobile application (version 4.5.0) was conducted using the camera system of a smartphone (iPhone 13; Apple, CA, USA) at a resolution of 1080p. The current version of the application uses a threshold of 0.1 m/s in the vertical direction to determine the start and end of repetitions. That is, repetitions began when the y-axis velocity exceeded 0.1 m/s and stopped when that velocity was below 0.1 m/s. The application does not detect movements made on the x-axis. A correction is applied in both the X and Z axis to determine the orientation of the phone, recording angle and distance to the barbell. To compare the metric characteristics of the application, the Vitruve LPT device (alias Speed4Lift, Madrid, Spain) was used, which in previous works satisfied a high level of validity and reliability (16). The device is attached to the bar with a strap using a pull-out rope. Data collected by the vertical displacement of the rope inside the device is sent via bluetooth connection to the device application (Vitruve Teams, version 1.29) connected to a tablet (iPad 10; Apple, CA, USA).

Figure 1. Metric VBT mobile application interface
Slika 1. Sučelje Metric VBT mobilne aplikacije

The observed variables in this study were: (1) mean or average velocity (m/s), (2) peak velocity (m/s) and (3) range of motion (cm). To determine the concurrent validity between the two measuring devices in the observed variables, Pearson's product-moment correlation coefficient (r) was used and rated as very weak (0.00 - 0.19), weak (0.20 - 0.39), moderate (0.40 - 0.59), strong (0.60 - 0.79) and very strong (0.80 - 1.00) correlation of variables. On the other hand, reliability was determined using the intraclass correlation coefficient (ICC) interpreting the results according to the scale: poor (<0.50), moderate (0.50 - 0.75), good (0.75 - 0.90) and excellent (>0.90) (13). Variations within the results of one subject were determined using the coefficient of variation (CV) and the accepted level of variability was set at <10% (4). The standard error of measurement (SEM) was determined using a t-test for dependent samples, while the Bland-Altman plot graphically showed the potential level of systematic error between the two measuring devices. The level of statistical significance was set at $p < 0.05$. All data were statistically processed in IBM SPSS software (version 27, SPSS Inc., an IBM Company, Chicago, IL, USA).

RESULTS

Due to difficulties and inability to read values during the research at a load of 30% of 1RM, this value was excluded from further statistical analysis and processing for all subjects. Later statistical analysis included values of 45%, 60% and 75% of 1RM in all variables.

All data are presented as mean ± standard deviation values. Analysis of the total number of repetitions of all subjects (135) using Pearson's product-moment correlation coefficient (r) established a statistically significant, strong and very strong correlation between the two measuring devices in the variables of mean velocity ($r = 0.93$; $p < 0.05$; Figure 2), peak velocity ($r = 0.91$; $p < 0.05$; Figure 3) and range of motion ($r = 0.75$; $p < 0.05$; Figure 4). Also, the load – velocity relationship for the Metric VBT measuring device was measured using a linear regression equation between the average movement velocity (m/s) at given loads (45%, 60% and 75% of 1RM) for the variables of mean velocity ($R^2 = 0.999$; $p < 0.05$) and peak velocity ($R^2 = 0.989$; $p < 0.05$).

Table 1. shows the values of validity and reliability for individual loads in the mean velocity variable (m/s). The results show a statistically significant ($p < 0.05$), moderate and strong correlation between the two measuring devices for loads of 45% ($r = 0.47$), 60% ($r = 0.85$) and 75% ($r = 0.89$) of 1RM. Also, reliability for individual repetitions in the observed loads for the Metric VBT device indicates the existence of excellent consistency and low variability of results for 45% (ICC = 0.929; CI = 0.831 - 0.974; CV = 3.91%), 60% (ICC = 0.952; CI = 0.887 - 0.983; CV = 4.74%) and 75% (ICC = 0.945; CI = 0.869 - 0.980; CV = 7.09%) of 1RM.

Table 1. Results of validity and reliability in the variable of mean velocity (m/s)

Tablica 1. Rezultati valjanosti i pouzdanosti u varijabli srednje brzine (m/s)

%1RM	r	ICC (95% CI)	CV (%)
45	0,47	0,929 (0,831-0,974)	3,91
60	0,85	0,952 (0,887-0,983)	4,74
75	0,89	0,945 (0,869-0,980)	7,09

Legend: 1RM = one-repetition maximum; r = Pearson's correlation coefficient; ICC = intraclass correlation coefficient; CV = coefficient of variation

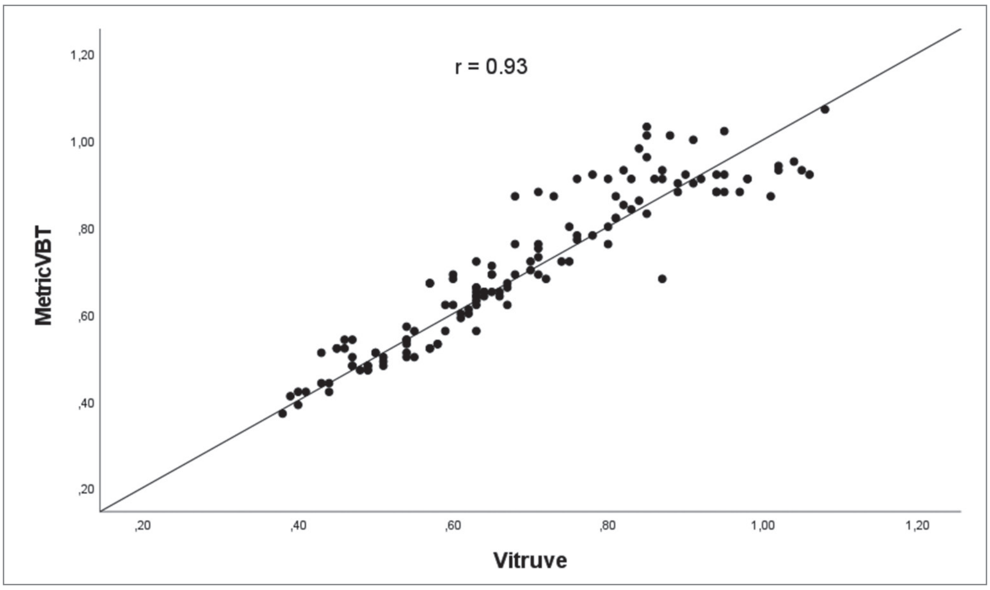

Figure 2. Correlation between two measuring devices in the variable of mean velocity (m/s)

Slika 2. Povezanost između dva mjerna uređaja u varijabli srednje brzine (m/s)

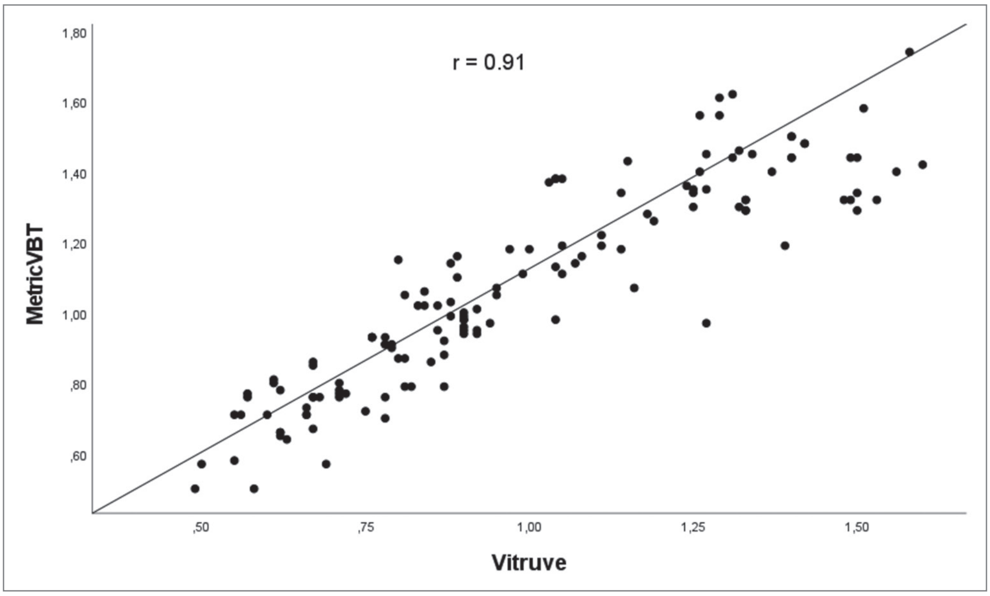

Figure 3. Correlation between two measuring devices in the variable of peak velocity (m/s)
Slika 3. Povezanost između dva mjerna uređaja u varijabli vršne brzine (m/s)

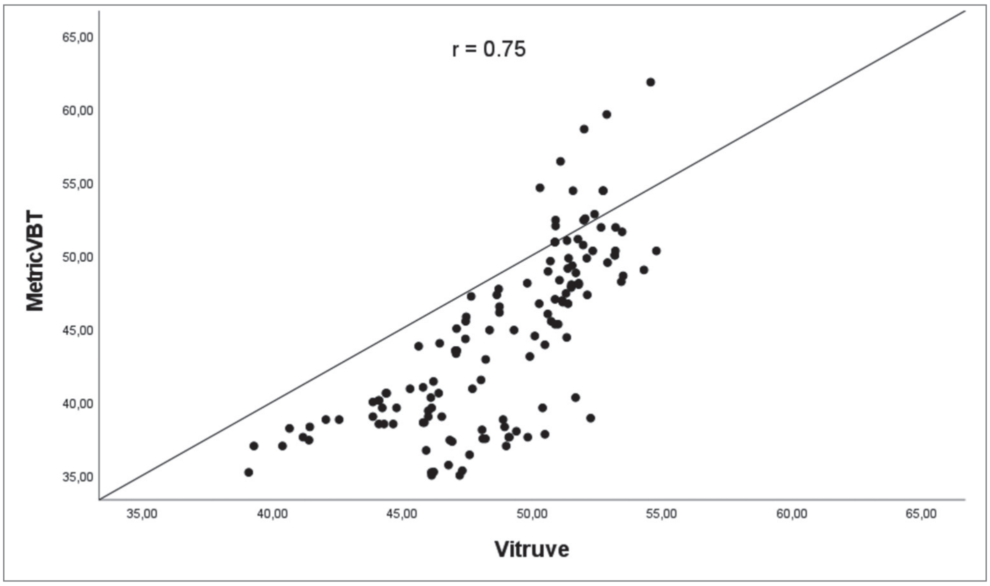

Figure 4. Correlation between two measuring devices in the variable of range of motion (cm)
Slika 4. Povezanost između dva mjerna uređaja u varijabli amplitude pokreta (cm)

Table 2. shows the values of validity and reliability for individual loads in the peak velocity variable (m/s). The results show a statistically significant ($p < 0.05$), strong and very strong correlation for 60% ($r = 0.79$) and 75% ($r = 0.81$) of 1RM, while the value of 45% 1RM does not achieve a statistically significant correlation ($r = 0.28$; $p > 0.05$). Also, reliability for individual repetitions in the observed loads indicates the existence of excellent consistency and low variability of results for 45% (ICC = 0.893; CI = 0.747 - 0.961; CV = 4.90%), 60% (ICC = 0.966; CI = 0.920 - 0.988; CV = 5.94%) and 75% (ICC = 0.921; CI = 0.813 - 0.971; CV = 9.41%) of 1RM.

Table 2. Results of validity and reliability in the variable of peak velocity (m/s)
Tablica 2. Rezultati valjanosti i pouzdanosti u varijabli vršne brzine (m/s)

%1RM	r	ICC (95% CI)	CV (%)
45	0,28	0,893 (0,747-0,961)	4,90
60	0,79	0,966 (0,920-0,988)	5,94
75	0,81	0,921 (0,813-0,971)	9,41

Legend: 1RM = one-repetition maximum; r = Pearson's correlation coefficient; ICC = intraclass correlation coefficient; CV = coefficient of variation

Table 3. shows the values of validity and reliability for individual loads in the range of motion variable (cm). The results show a statistically significant ($p < 0.05$) strong correlation between the two measuring devices for loads of 45% (r = 0.71), 60% (r = 0.79) and 75% (r = 0.77) of 1RM. Also, reliability for individual repetitions in the observed loads indicates the existence of excellent consistency and low variability of results for 45% (ICC = 0.970; CI = 0.928 - 0.989; CV = 3.91%), 60% (ICC = 0.954; CI = 0.892 - 0.983; CV = 3.12%) and 75% (ICC = 0.974; CI = 0.938 - 0.991; CV = 3.07%) of 1RM.

Table 3. Results of validity and reliability in the variable of range of motion (cm)

Tablica 3. Rezultati valjanosti i pouzdanosti u varijabli amplitude pokreta (cm)

%1RM	r	ICC (95% CI)	CV (%)
45	0,71	0,970 (0,928-0,989)	3,91
60	0,79	0,954 (0,892-0,983)	3,12
75	0,77	0,974 (0,938-0,991)	3,07

Legend: 1RM = one-repetition maximum; r = Pearson's correlation coefficient; ICC = intraclass correlation coefficient; CV = coefficient of variation

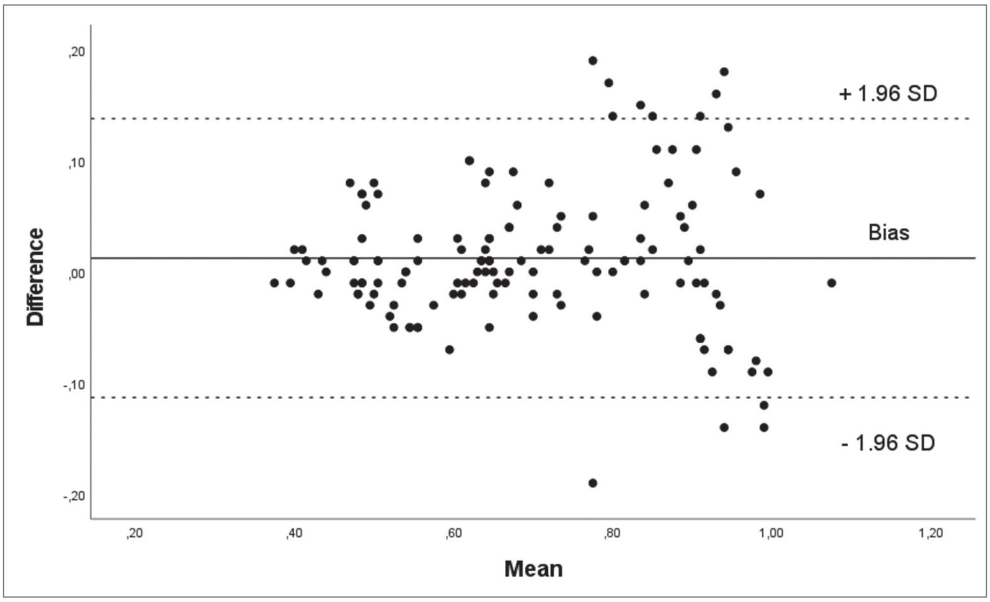

Figure 5. Bland – Altman plot between two measuring devices in the variable of mean velocity (m/s)

Slika 5. Bland – Altman dijagram između dva mjerna uređaja u varijabli srednje brzine (m/s)

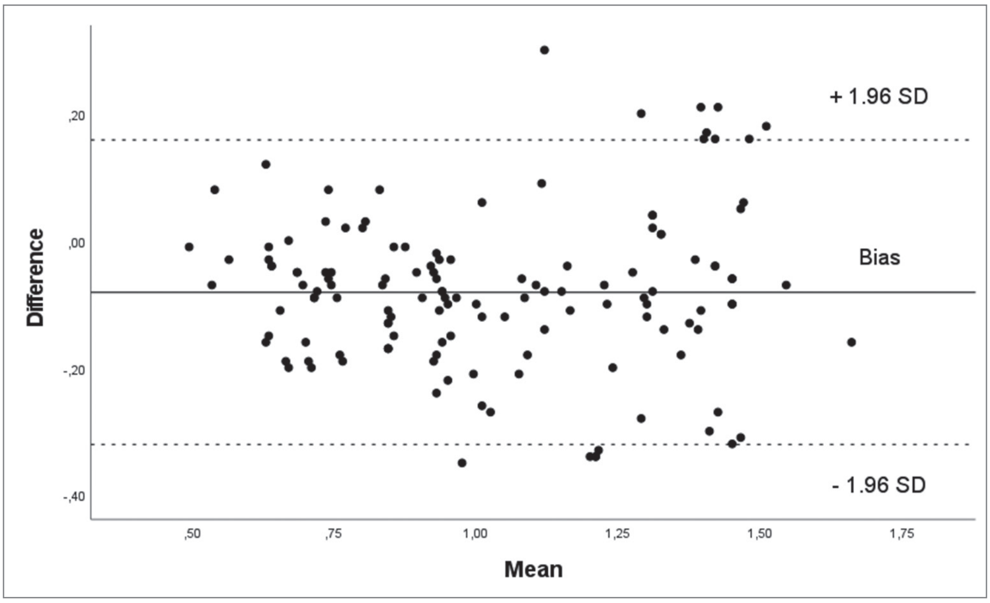

Figure 6. Bland – Altman plot between two measuring devices in the variable of peak velocity (m/s)

Slika 6. Bland – Altman dijagram između dva mjerna uređaja u varijabli vršne brzine (m/s)

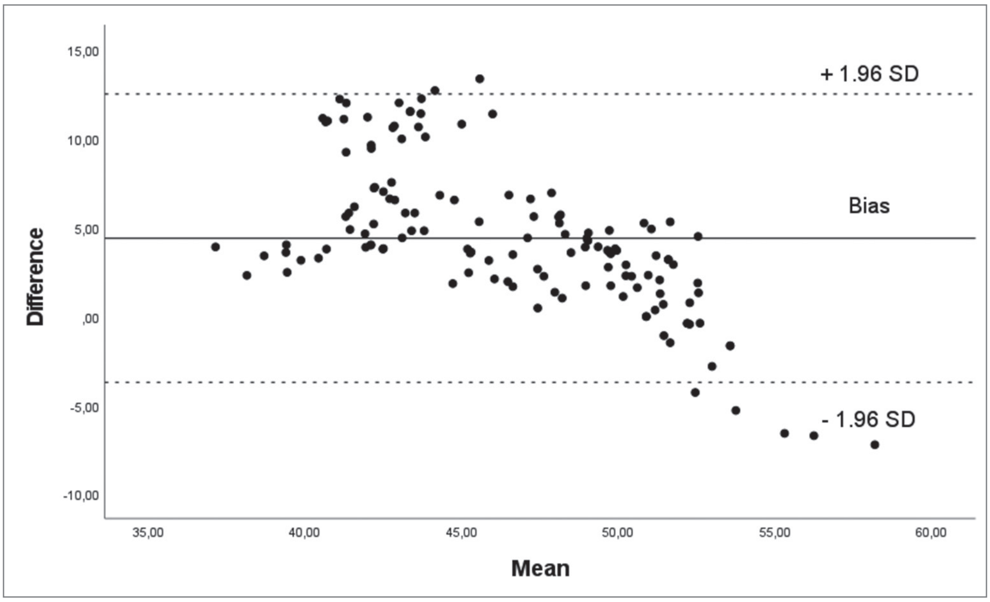

Figure 7. Bland – Altman plot between two measuring devices in the variable of range of motion (cm)
Slika 7. Bland – Altman dijagram između dva mjerna uređaja u varijabli amplitude pokreta (cm)

The t-test for dependent samples determined the level of standard error of measurement (SEM) for the variables of mean velocity (Metric VBT = 0.70 ± 0.18 m/s; Vitruve = 0.69 ± 0.17 m/s; SEM = 0.01 ± 0.06 m/s; $p < 0.05$), peak velocity (Metric VBT = 0.99 ± 0.30 m/s; Vitruve = 1.06 ± 0.29 m/s; SEM; -0.08 ± 0.12 m/s; $p < 0.05$) and range of motion (Metric VBT = 48.79 ± 3.47 cm; Vitruve = 44.40 ± 6.04 cm; SEM = 4.38 ± 4.14 cm; $p < 0.05$), which leads to the conclusion about the existence of a statistically significant overestimation of values for the variables of mean velocity and range of motion, and underestimation of values for the peak velocity variable by the Metric VBT device.

The Bland-Altman plots graphically show the levels of systematic error for the variables of mean velocity (Figure 5), peak velocity (Figure 6) and range of motion (Figure 7). The x-axis shows the mean values of the two measuring devices, while the y-axis shows their differences expressed in standard deviation (SD) values. The central line represents the systematic error between the two measuring devices, while the upper and lower dashed lines represent the limit of ± 1.96 SD.

DISCUSSION

The results of this study indicate that the Metric VBT measuring device is statistically significantly ($p < 0.05$) valid and reliable in the variables of mean (m/s) and peak (m/s) velocity and range of motion (cm) at loads of 45%, 60% and 75% of 1RM in the bench press exercise.

The initial idea of the research was to test the metric characteristics at 30% of 1RM along with the mentioned loads. However, due to difficulties in reading values during repetition performance, this value was excluded from further statistical processing. The reason for this outcome can be explained by the fact that smaller loads require the use of bumper plates with a shorter diameter which the mobile camera system has more difficulty detecting. Given that almost all subjects were recreational exercisers, it was harder to expect a higher level of 1RM. Additionally, repetitions performed at high movement velocities are prone to greater systematic error in mobile applications for VBT compared to other devices (14). These results are contrary to findings obtained by other researchers stating that mobile applications for VBT achieve a very strong correlation at lower loads and higher movement velocities in some velocity variables across different exercises (15, 22).

On the other hand, it was observed that the Metric VBT measuring device achieves a statistically significant strong and very strong correlation in the variables of mean velocity ($r = 0.93$; $p < 0.05$), peak velocity ($r = 0.91$; $p < 0.05$) and range of motion ($r = 0.75$; $p < 0.05$) taking into account the total number of repetitions at all loads, which is in line with previous research on mobile applications for VBT (2,5,22). At the same time, attention needs to be directed to individual loads where 45% of 1RM achieves weak to moderate correlation in the variables of mean ($r = 0.47$) and peak velocity ($r = 0.28$), which cautions against using the measuring device for these loads in the observed variables. The difference is made by loads of 60 and 75% of 1RM which show a statistically significant ($p < 0.05$) strong to very strong correlation for the variables of mean ($r = 0.85 - 0.89$) and peak velocity ($r = 0.79 - 0.81$) and range of motion ($r = 0.77 - 0.79$), whereby these results gain practical significance and indicate high confidence in their use.

In addition to the difference in correlation, the standard error of measurement (SEM) determined the level of systematic error between the two measuring devices for the variables of mean velocity (SEM = 0.01 ± 0.06 m/s; p

< 0.05), peak velocity (SEM = -0.08 ± 0.12 m/s; $p < 0.05$) and range of motion (SEM = 4.38 ± 4.14 cm; $p < 0.05$), which indicates a statistically significant overestimation of values for the variables of mean velocity and range of motion, and underestimation of values for the peak velocity variable. González-Badillo and Sánchez-Medina (9) explain that a change greater than 0.07 m/s in the mean velocity variable can indicate a change in strength level. Therefore, it is possible to claim that the mean velocity variable has an accepted level of systematic error. On the other hand, the peak velocity variable achieves a level of systematic error greater than 0.07 m/s and should therefore be used with caution. Such differences can be explained in terms of the characteristics of two separate measuring systems in which the LPT device achieves a sampling rate of up to 1000 Hz, while the mobile application using the smartphone camera system achieves a significantly lower sampling rate of 60 Hz, which has been discussed in previous research (8).

Speaking of reliability measured using the intraclass correlation coefficient (ICC) for individual repetitions, we come to the conclusion about the existence of excellent consistency of results of statistical significance ($p < 0.05$) at all loads (45%, 60% and 75% 1RM) in the variables of mean velocity (m/s), peak velocity (m/s) and range of motion (cm), which is consistent with previous research on VBT mobile applications (22, 20). Variations within the results of one subject explained using the coefficient of variation (CV) indicate an accepted level of variability (<10%) at all loads in the observed variables. The highest level of variability was recorded for loads of 75% 1RM in the variables of mean (7.09%) and peak (9.41%) velocity. Such results can be explained based on the inverse relationship between movement velocity and the load being overcome, where each increase in load or number of repetitions leads to the appearance of fatigue resulting in a decrease in movement velocity, whereby this assumption suggests that greater variability may not necessarily be a product of the measuring instrument, but of the human (23). Ultimately, the mobile application satisfies a high level of reliability for individual repetitions and acceptable variability of results, making it metrically justified and safe to use.

This work did not pass without limitations. One of them is defining 1RM in the bench press exercise verbally among the subjects. The reason for this choice was logistical in which the duration of testing was intended to be reduced to one day. Thus, possible consequences are in terms of incorrect assessment of maximum strength which can result in underestimation or overestimation of results in the observed variables and affect the incorrect interpretation of results. Also, we did not want to conduct 1RM testing and profiling of subjects within the same day due to possible transfer of fatigue from one protocol to another. Likewise, testing was conducted in an exercise with free weights where there is greater variability of results compared to exercising on machines due to greater freedom of movement. This assumption is not considered a major disadvantage given that in practical conditions VBT is used with a wide range of exercises in which the use of free weights predominates. The next limitation appears in terms of not conducting test-retest reliability where it is necessary to define the consistency of data between multiple days, which is also very important in terms of practical significance. Future research should, along with all the mentioned limitations, turn to examining the metric characteristics of the mobile application in ballistic exercises such as loaded jumps and various derivatives of Olympic lifts which very often tend to be the backbone of training programs, and about which there are still no studies of such format.

CONCLUSION

The aim of this paper was to determine the metric characteristics of validity and reliability of the Metric VBT mobile application in relation to an LPT device in the bench press exercise. The results of the research indicate statistically significant ($p < 0.05$) validity and reliability of the mobile application for VBT at loads of 45%, 60% and 75% of 1RM in the variables of mean velocity (m/s), peak velocity (m/s) and range of motion (cm), whereby the first and second hypotheses of the research are accepted. A statistically significantly higher level of validity measured using the correlation coefficient (r) was achieved for loads of 60% and 75% of 1RM in all variables, suggesting the use of the mobile application for higher loads given that there is a possibility of reading incorrect results or not reading data at all at lower loads. The level of standard error of measurement (SEM) determined an acceptable deviation of results in the mean velocity (m/s) variable, while in the peak velocity (m/s) variable there is a higher level of deviation whereby this variable should be evaluated with caution. Reliability measured by the intraclass correlation coefficient (ICC) and coefficient of variation (CV) indicates the existence of excellent repeatability and low variability of results in all variables and at all loads. These findings suggest that despite the existence of systematic error and moderate to strong correlation at all loads in some variables, the mobile application becomes practically justified thanks to very high levels of reliability. In real conditions, reliability becomes a much more important characteristic than validity because if the measuring instrument consistently shows the same systematic error, while being consistently consistent in terms of results, then it is possible to track the trend of changes if the training process is carried out under the same conditions. However, in the future it is necessary to conduct more extensive scientific research that includes a sample of female subjects, other variants of complex exercises such as squats and deadlifts, as well as the application of various ballistic type exercises such as cleans, snatches and determining test-retest reliability.

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