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"IDO MOVEMENT FOR CULTURE. Journal of Martial Arts Anthropology",
Vol. 21, no. 1 (2021), pp. 12–18
DOI: 10.14589/ido.21.1.3

KINESIOLOGY / COACHING

Marcos Antonio Pereira dos Santos[1(ADE)],
Christian Emmanuel Torres Cabido[2(ACD)], Valmir Oliveira Silvino[1(ABCDEF)],
Andre Rodrigues de Mesquita[1(ABE)], Francisco Luís Santos do Nascimento[1(ABE)],
Severino Leao de Albuquerque Neto[3(ACD)],
Karine Naves de Oliveira Goulart[4(B)], Leszek Antoni Szmuchrowski[4(AE)],
Bruno Couto Pena[4(AE)]

1 Department of Biophysics and Physiology, Nucleus of Study in Physiology Applied to Performance and Health (NEFADS), Federal University of Piaui (UFPI) (Brazil)
2 Federal University of Maranhao (UFMA) (Brazil)
3 Catholic University of Brasila (UCB/DF) (Brazil)
4 Federal University of Minas Gerais (UFMG) (Brazil)
Corresponding author: Valmir Oliveira Silvino
3700 Pedro Freitas Avenue, Zip code: 64018-000 Teresina – PI, Brazil
Tel. +55 86 988524880, e-mail: valmirsilvino@live.com

Validity of the Polar V800 to measure vertical jump performance in taekwondo athletes

Submission: 3.12.2019; acceptance: 26.01.2020

Key words: squat jump, countermovement jump, force plate, martial arts

Abstract

Background. Lower limbs performance plays a huge role in the training processes of martial arts, including taekwondo. By monitoring vertical jumps (VJ) lower limb muscular strength can be assessed. However, the force plate, considered the gold standard device to evaluate VJ performance, is expensive and lab-based. The Polar V800 device is able to measure VJ height, and it has become widely popular among trainers and athletes. However, it has not yet been validated for this purpose.

Problem and aim. Due to the impracticability of using the force plate, coaches and athletes have been using the Polar V800 in their training routines. This study aimed to evaluate the validity and reliability of the Polar V800 versus force plate measurements to estimate VJ height in taekwondo athletes.

Methods. Thirty male national level taekwondo athletes were asked to perform five squat jumps and five countermovement jumps at maximal effort on the force plate while simultaneously wearing the stride sensor connected to the V800. The mean and the highest jump measurements estimated simultaneously by both devices were compared through Pearson's correlation and Bland-Altman test.

Results. Intraday reliability of the V800 was excellent with ICCs ranging from 0.97 to 0.98. There was strong reliability (ICC > 0.97), a low standard error of measurements (0.69 - 0.92 cm), an excellent correlation between methods (r > 0.96), and excellent agreement observed by Bland-Altman analysis.

Conclusion. The Polar V800 device is demonstrated to be a valid and reliable tool for the estimation of VJ height.

Introduction

The monitoring of vertical jump (VJ) performance is one of the most common methods to assess performance [Suchomel, Lamont, Moir 2016] and neuromuscular status [Claudino *et al.* 2017] of lower limbs in athletes. Among the several types of VJ, squat jump (SJ) and countermovement jump (CMJ) are the most widely used by researchers, health professionals, and athletes to monitor athletic performance and strength of the lower limbs [Yousfi *et al.* 2018]. However, the assessment of VJ performance is still restricted due to the high cost and the lab-based nature of devices, such as force plate [Kons *et al.* 2018] and contact mat [Almeida *et al.* 2018]. Therefore, cheaper alternatives with high levels of accuracy and reliability could increase the possibility of assessing VJ performance in the sports field, which would decrease the use of unreliable methods of evaluation [Pereira *et al.* 2009].

Muscular strength of the lower limbs plays a huge role in many sports, including martial arts such as taekwondo [Costa *et al.* 2018]. In taekwondo sparring competition, athletes move by leaping around in small amplitudes, which involves the activation of the stretch-shortening cycle (SSC) [Bridge, Ferreira, Chaabe 2014]. The strength of the lower limb muscles is usually assessed through the SJ and CMJ tests [Stojanović *et al.* 2017]. During the SJ, it is possible to evaluate the contractile capacity of the muscle, as the athlete starts the jump in a squatting position, keeps in this position for three seconds and then engages the jump explosively (ascending phase) [Van Hooren, Zolotarjova 2017]. On the other hand, the CMJ allows to evaluate the capacity of using the SSC [Van Hooren, Zolotarjova 2017], as the descending phase is immediately followed by the ascending phase [Cheraghi *et al.* 2017]. Thus, as the concentric muscle strength [Bridge, Ferreira, Chaabe 2014; Kons *et al.* 2018] and SSC activation [Cheraghi *et al.* 2017] of the lower limbs play an important role in athletic performance, the monitoring of SJ and CMJ performance may provide significant information in training prescription and load control processes.

Force plates, which calculate muscular strength and the impulse of the lower limbs [Glatthorn *et al.* 2011], are considered the gold standard for the estimation of VJ performance [Cronin, Hing, McNair 2004]. However, force plates are expensive and laboratory-based, which makes their use impractical in field-based assessments. In fact, due to the recent technological advancements, several alternative devices have been created in order to assess SJ and CMJ heights, and many studies have been carried out to assess their validity and reliability. Among these devices are the VERT device [Manor, Bunn, Bohannon 2018], Ergojump contact mat [Rago *et al.* 2018], Chronojump-Boscosystem and Globus Ergo Tester jump-mat systems [Pueo *et al.* 2017], Optojump optical device [Attia *et al.* 2017], Myotest accelerometer [Choukou, Laffaye, Taiar 2014], as well as the smartphone apps My Jump [Cruvinel-Cabral *et al.* 2018] and My Jump 2 [Coswig *et al.* 2019].

Another device that hit the market was the Polar V800, which is capable of recording speed, heart rate, and geolocation (GPS). The V800 has the advantages of being user-friendly, portable, and cost-effective. Since its introduction in 2014, the V800 has been largely used for field-based evaluations of VJ performances. The Polar V800 has already been validated regarding the assessment of energy expenditure [Roos *et al.* 2017], and RR intervals in individuals at rest [Giles, Draper, Neil 2015], and mountain running conditions [Caminal *et al.* 2018]. However, there are no studies assessing the validity of the Polar V800 in measuring the height of SJ and CMJ. Therefore, this study was conducted to assess the validity of the Polar V800 monitor as a suitable device for measuring VJ performance in taekwondo sparring athletes.

Methods

Subjects

Thirty male national-level taekwondo athletes (no injury history, age: 21.70 ± 2.97 years old, body mass: 66.54 ± 9.12 kg, height: 173.00 ± 5.29 cm) participated in the study. The study was carried out following the ethics principles, and it was approved by the local ethics committee of human research, protocol number 2,379,617. All participants provided written Informed Consent Forms before the testing and they were asked to refrain from strenuous exercise 24 hours before the assessments. Individuals who had gone through surgery at least six months prior to the research or presented any adversity that would impair the maximum performance of the VJs were excluded from the study.

Methodology

The study was carried out in two stages. Initially, all volunteers were instructed how to perform VJs and then allowed time for a standardized warm-up session that consisted of slight stretching and mobilization of the lower limbs. Afterward, the participants were familiarized with the VJ procedure, which consisted of 5 jumps under the supervision of three researchers. There was a 60s recovery time between each attempt. All jumps were performed on the force plate on which the tests were carried out. The familiarization process took place one day before the tests of the study.

In the second stage, the volunteers were anthropometrically evaluated (age, height, and weight). Subsequently, the Polar Stride Sensor Bluetooth Model Y8 device (Polar Electro OY, Kempele, Finland) was attached to the shoe of the participant according to the manufacturer's manual procedure. Afterward, the volunteers performed 5 SJs and 5 CMJs, and all values were registered. There was a rest interval of 60 seconds between each jump repetition and 2 minutes between the jump series [Van Hooren, Zolotarjova 2017].

For the SJ, the subjects were asked to keep their hands on their hips, flex their knees (approximately 90º), and keep this position for 3 seconds. After the command, they jumped vertically as high as possible. For the CMJ, they kept their hands on their hips in an upright standing position. After the command, starting from orthostatic posture, they flexed their knees (approximately 90º) as fast as possible and immediately jumped vertically as high as possible. In both jump modalities, they kept their hands on their hips in order to avoid interference of the arm swing on the jump performance. Knees and ankles were completely extended from the moment of the take-off to the landing. Three researchers evaluated the correctness of the movements. If at least one researcher considered the movement inappropriate, the jump would be discarded.

All jumps were performed using the Polar Stride Sensor Bluetooth Model: Y8 (Polar Electro OY, Kempele, Finland) on the force plate (PLA3-1D-7KN/JBA) (Zb. Staniak®, Poland, 1000 Hz,®), so that both devices could evaluate the performance of the same jump simultaneously. Data obtained by the stride sensor were registered by the Polar V800 device (Polar Electro OY, Kempele, Finland), and data obtained by the force plate were registered by the software MVJ (version 5.5, Zb.Staniak®, Poland). The sensors of the force plate measured the force applied, and the software used the impulse obtained (impulse = force x time) to calculate the maximum speed of the take-off (speed x mass = force x time) and the height of the VJ (height = maximum speed of the take off² / 2 x gravitational acceleration) [Ferreira, Carvalho, Szmuchrowski 2008]. Both the highest jump and the average of the five attempts were used for validity analysis.

Data Analysis

Normality and homogeneity of the data variance were analyzed with Shapiro-Wilk and Levene tests, respectively. The intraclass correlation coefficient (ICC) and the Standard Error of the Measurements (SEM) were used to verify the reliability. Pearson's correlation coefficient was used to assess how strongly the values resemble each other. The correlation magnitude adopted was: "very low" (0.00 – 0.25), "low" (0.26 – 0.49), "moderate" (0.50 – 0.69), "strong" (0.70 – 0.89), and "very strong" (0.90 – 1.00) [Portney, Watkins 2009]. Bland-Altman plot was used to verify the agreement between measurement methods. The significance level was established at $p < 0.05$ for all analyses. The entire statistical analysis was performed using the SPSS version 20.0 statistical software (SPSS Inc., Chicago, IL, USA).

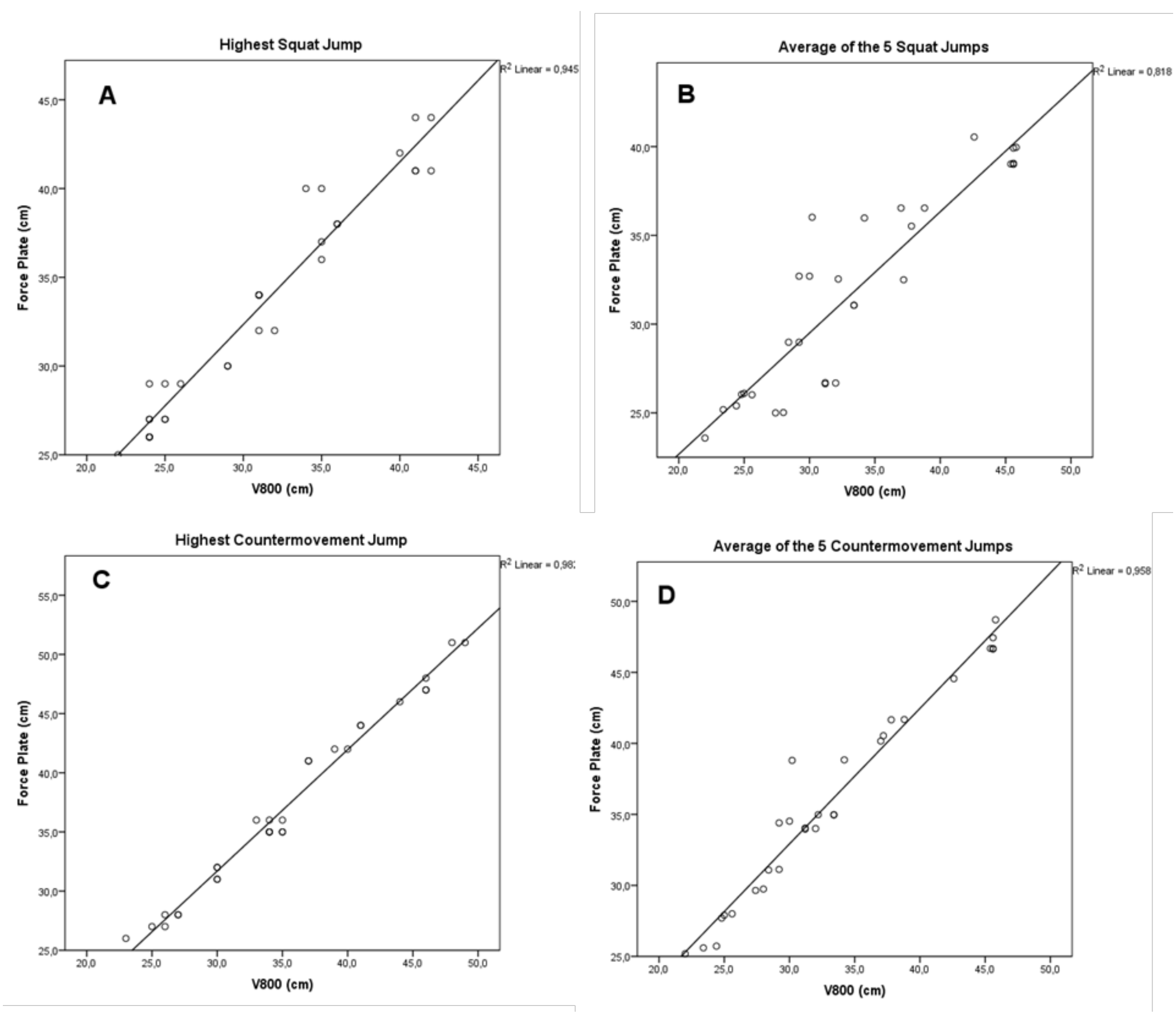

Figure 1. Correlation between the vertical jump performance estimated by the V800 and the force plate considering the highest squat jump (SJ) (A) and countermovement jump (CMJ) (C), as well as the averages of the 5 SJ (B) and CMJ (D).

Results

ICC showed a strong relationship between the repetitions for both jump modalities (ICC > 0.97, $p < 0.01$) for the V800. Moreover, the V800 showed excellent intraday reliability levels for all jump modalities (ICC > 0.97, $p < 0.001$) and low levels of SEM (0.69 – 0.92 cm) (Table 1).

There was a strong, positive, and significant correlation between the V800 and the force plate considering the highest jump and the average of the five attempts (Figure 1) for the SJ ($r = 0.97$; $p < 0.01$; $r = 0.97$; $p < 0.01$, respectively) and the CMJ ($r = 0.99$; $p < 0.01$; $r = 0.96$; $p < 0.01$, respectively).

Bland-Altman plots [Bland, Altman 1986] showed that the limits of agreement between the results obtained from both instruments were significantly similar, as the majority of the values are close to the mean of the differences between the two devices (Figure 2).

Table 1. Reliability of measurements for the performance of SJ and CMJ comparing the force plate and the V800.

Variable	$ICC_{(3,1)}$	CI (95%)	p	SEM (cm)	%
Average of the 5 SJ (cm)	0.97	0.85 – 0.96	<0.01	0.92	1.08
Highest SJ (cm)	0.97	0.85 – 0.97	<0.01	0.86	2.21
Average of the 5 CMJ (cm)	0.98	0.91 – 0.98	<0.01	0.69	1.5
Highest CMJ (cm)	0.99	0.80 – 0.98	<0.01	0.76	2.2

Notes: ICC: intraclass correlation coefficient; CI (95%): confidence interval at 95%; SEM: standard error of measurement; %: SEM percentage in relation to the mean; SJ: squat jump; CMJ: countermovement jump.

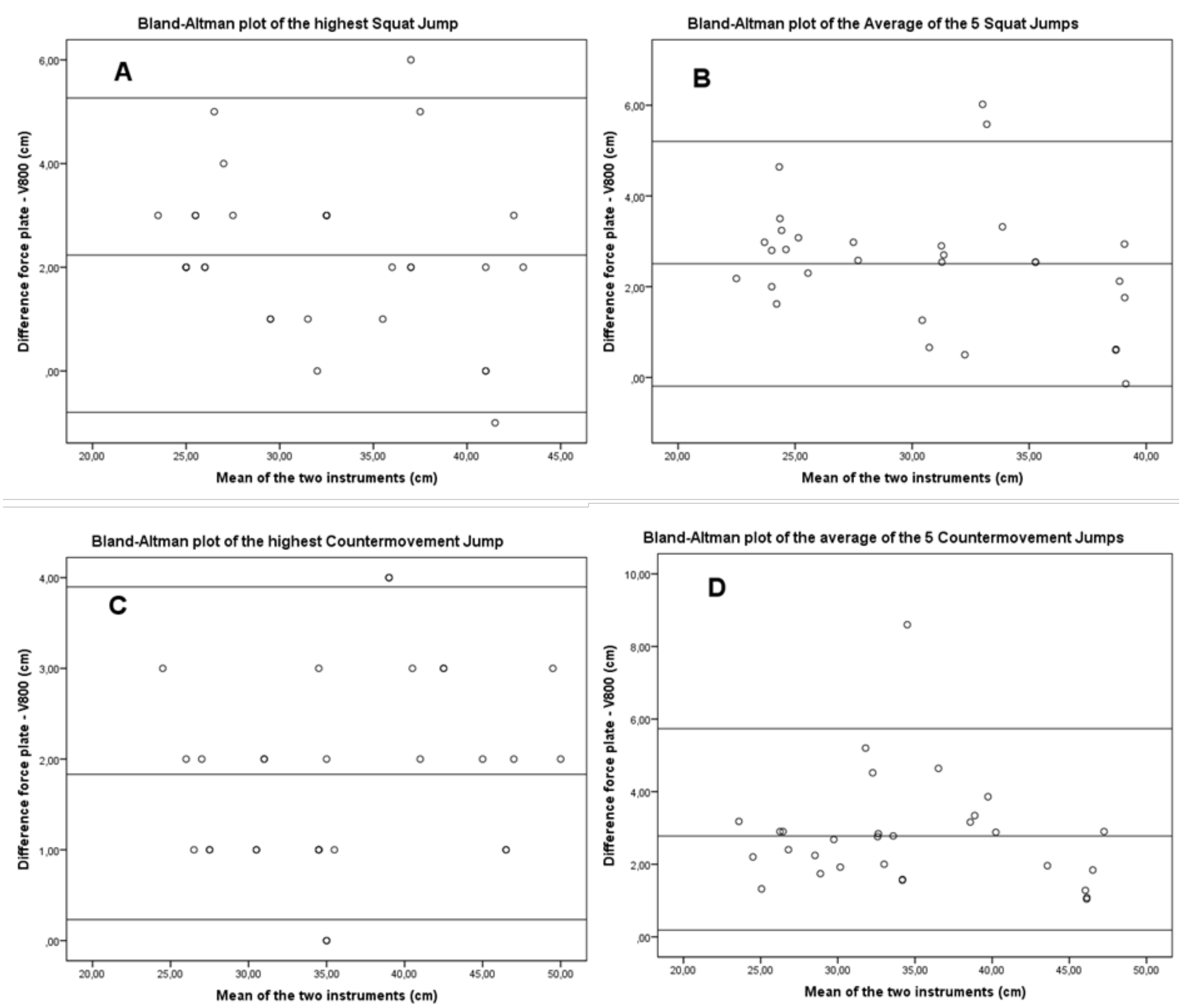

Figure 2. Bland-Altman scatterplot analysis of the difference and mean of measurements between vertical jump performances estimated by the V800 and the force plate considering the highest squat jump (SJ) (A) and countermovement jump (CMJ) (C), as well as the averages of the 5 SJ (B) and CMJ (D). The central line represents the average difference between instruments. Short-dashed lines represent the upper and lower 95% limits of agreement.

Discussion

In previous investigations, the correlation coefficient has been the most common method to evaluate validity and reliability. Moreover, it has been suggested that Bland-Altman plots test can also provide relevant information regarding the agreement between two measurement methods [Bland, Altman 1986]. To the best of our knowledge, this is the first study attempting to validate the V800 for the estimation of jump performance. The measurements obtained with the Polar V800 have concurrent validity against the force plate with ICC values greater than 0.97 and correlation coefficients greater than 0.96 for all analyses. Moreover, there was a strong coefficient of determination ($R^2 > 0.81$) and a strong agreement between the V800 and the force plate, as most of the SJ and CMJ values are close to the difference of the mean between the instruments. SEM values were low (< 0.92), which indicates excellent intraday reliability of the measurements evaluated [Weir 2005].

The result of this study regarding the analysis of reliability the correlation was considered very strong (ICC > 0.97 and r > 0.96, respectively), and these values are equal or higher than those found in similar studies [Cronin, Hing, McNair 2004; Choukou, Laffaye, Taiar 2014; Manor, Bunn, Bohannon 2018; Rago *et al.* 2018]. In the present study, the average difference between measurement methods was similar to the values found in a previous study that assessed the validity of an accelerometer in measuring VJ performance [Choukou, Laffaye, Taiar 2014]. Whereas Choukou, Laffaye, and Taiar [2014] evaluated the vertical performance of physiotherapy and physical education students with no previous experience in activities involving jumping, the current study used taekwondo athletes as participants. Therefore, the similarity in the results may indicate that the experience of the subjects in the jumping activity does not affect the reliability and validity of these portable devices in measuring the performance; thus, they can be used in both athletic and nonathletic populations.

Conclusions

The Polar V800 device has become a popular tool among athletes and coaches for measuring several parameters, including VJ heights, such as SJ and CMJ. This study compared the parameters obtained simultaneously with the device Polar V800 and a force plate, the gold standard in the evaluation of VJ performance. Our data suggest that the Polar V800 device can be used to assess the height of VJs with the same accuracy of the force plate in taekwondo athletes. Due to its practicability, it can be used by coaches, athletes, and the general population to measure jump heights quickly. This evaluation could provide valuable information for training control, neuromuscular fatigue, and prediction of injury risk of the lower limbs, therefore assisting the performance improvement in taekwondo athletes and potentially other combat sport athletes.

Narrow limits of agreement and a strong correlation between both devices were observed. Although the Polar V800 underestimated the values of the SJ and CMJ, there was a strong agreement when compared to the force plate. The Polar V800 is therefore a valid device for estimating VJ performance. The benefit of this study is that it validated a device that offers a variety of functions for field-based analysis, including the estimation of VJ height. Considering the important role of the lower limb performance in martial arts in general and taekwondo in particular, the Polar V800 can be used in load prescription and as a training control with the same accuracy of a force plate. A limitation of the present study was the use of a small sample population. Further investigations are needed in order to demonstrate the reliability of the Polar V800.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The authors gratefully thank the athletes and coaching staff for their contribution to this study.

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Zasadność zastosowania urządzenia Polar V800 do pomiaru wydajności skoków w pionie zawodników taekwondo

Słowa kluczowe: skok z przysiadu, skok z obrotem, talerz do treningu siłowowego, sztuki walki

Streszczenie

Tło. Wydajność kończyn dolnych odgrywa ogromną rolę w procesie treningu sztuk walki, w tym taekwondo. Monitorowanie skoków pionowych (VJ) pozwala na ocenę siły mięśni kończyn dolnych. Jednak talerz do treningu siłowego, uważany za złoty standard urządzenia do oceny wydajności VJ, jest kosztowny i działający w warunkach laboratoryjnych. Urządzenie Polar V800 jest w stanie mierzyć wysokość wyskoku VJ i stało się ono bardzo popularne wśród trenerów i sportowców. Jednak nie uzyskało jeszcze zatwierdzenia.

Problem i cel. Ze względu na niepraktyczność talerza do treningu siłowego, trenerzy i sportowcy używają urządzenia Polar V800 w swojej rutynie treningowej. W związku z tym, niniejsze badanie miało na celu ocenę ważności i wiarygodności zastosowania urządzenia Polar V800 z pomiarem siłownika do szacowania wysokości skoku pionowego zawodników taekwondo.

Metody. Trzydziestu zawodników taekwondo na poziomie klasy narodowej zostało poproszonych o wykonanie pięciu skoków z przysiadu i pięciu skoków z obrotem przy maksymalnym wysiłku na talerzu do treningu siłowego, przy jednoczesnym użyciu czujnika skoku podłączonego do urządzenia V800. Średnie i najwyższe skoki zostały oszacowane jednocześnie przez oba urządzenia i porównane za pomocą korelacji Pearsona i testu Bland-Altmana.

Wyniki. Niezawodność śróddzienna V800 była doskonała przy współczynnikach ICC w zakresie od 0,97 do 0,98. Stwierdzono silną wiarygodność (ICC > 0,97), niski błąd standardowy pomiarów (0,69 - 0,92 cm), doskonałą korelację między metodami (r > 0,96) oraz doskonałą zgodność obserwowaną w analizie Bland-Altmana.

Wniosek. Urządzenie Polar V800 okazało się być ważnym i wiarygodnym narzędziem do szacowania wysokości skoku pionowego (VJ).