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Validity and reliability of the Iranian force plate

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Abstract

Background: Force plates are widely used in biomechanics and sports sciences to measure various aspects of human movement. The accuracy and reliability of force plate measurements are critical for valid data interpretation.

Aim: The purpose of the study was to evaluate the validity and reliability of the Iranian force plate in the vertical, anterior-posterior, and medial-lateral directions using two manual dynamometers and a load cell.

Materials and Methods: In this study, the force plate device utilized had a frequency of 1200 Hz and was manufactured by the Danesh Salar Iranian Company. Additionally, to determine the device's validity, we used Lafayette hand-held dynamometers manufactured in the United States and a load cell by Zemik. Pearson's correlation coefficient was employed to determine the validity of the force plate, while the internal consistency coefficient (ICC) was used to assess the force plate's reliability.

Results: The study findings indicated a significant and high level of reliability between the maximum force obtained from the force plate device and manual dynamometer devices and load cell. Additionally, the internal consistency coefficient was found to be excellent (very high) for 20 trials in the three directions of vertical (0.98), anterior-posterior (0.96), and medial-lateral (0.97).

Conclusion: The study demonstrated that the Iranian force plate is a reliable device for measuring maximum force in the three directions of vertical, anterior-posterior, and medial-lateral, with very high validity.

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1. Introduction

The implementation of the laboratory research base on the control of the conditions can provide the basis for the advancement of information in various sciences and the development of relevant theories. Among different sciences, sports science can play an essential role due to its interdisciplinary nature and its importance in the health of society [1, 2, 3, 4].

Sports biomechanics analysis during training and competition has increased significantly in recent years. Technology advancements may help create effective interventions to improve performance, develop equipment, and prevent injuries [1, 2, 3, 4]. One of the devices used in the biomechanical field is the force plate, which is used to measure the ground reaction force.

The simple force plate devices only measure the vertical component of the ground reaction force. However, the more advanced models also evaluate the three-dimensional components of the ground reaction force, the center of pressure, and the vertical force moment. These measurements can provide a perspective of the interaction between the athlete and the field [5].

The force plate plays an essential role in evaluating external forces in various tasks such as walking [6, 7], running [8, 9], sprint start [10, 11], jumping and landing [7, 12], and swimming start [13, 14]. To expand the use of kinetic tools, researchers and manufacturers are searching for more usable and less expensive alternative tools.

Therefore, Iranian manufacturers have made a force plate that is cheaper than the foreign model. after the construction and introduction of any new measurement device, it is necessary to provide information on its validity and reliability.

Validity is the degree of accuracy of the results of the measurement tool and shows how well the tool measured what it intended to measure. On the other hand, reliability is a degree of the sameness of the results during a specific time, under the same conditions, and with the same method [15, 16]. To determine the accuracy of a new device, it can compare its result with a golden standard. One tool used to measure force is the Lafayette Manual Muscle Testing (MMT) that can measure the maximum force [17, 18]. Also, the load cell can measure and convert force and pressure into standard electrical signals made in tensile, bending, compressive, and torsional types [19].

A base on force plate is one of the devices required by sports biomechanics and sports injury laboratories in order to test the athlete's performance and pathomechanics of sports injuries; therefore, the purpose of this study is to determine the validity and reliability of the vertical components., anterior-posterior and internal-lateral Iranian force plate that is manufactured by Danesh Salar Iranian company by dynamometer and load cell.

2. Methods

This study used the force plate manufactured by Danesh Salar Iranian company. This device was circular in shape and had a height of 193 mm and a diameter of 450 mm, and a weight of 24 kg.

The sampling rate was 1200 Hz, and it measured the force in three directions anterior-posterior (Fx), medial-lateral (Fy), and vertical (Fz) (measurement range in x and y direction, 500 kg and in z was 1200 kg).

On the other hand, the standard devices used in this study included hand-held dynamometers and load cells. The

dynamometer used in this study was made in the United States (Lafayetee-model: 01163), which could measure the maximum force applied.

Also, the load cell manufactured by Zemik company (model: H3-C3-250kg-3B-D55) was used with dimensions of length: 50.8, width: 27.2, and height: 76.2 mm and the tension and compression load cells type.

The force plate was fixed on the ground using a screw to perform the test. A subject used a manual muscle test device 20 times to make fore in the anterior-posterior, medial-lateral and vertical direction.

Also, this procedure was done with the load cell which in this case the load cell was fixed to a holder and the amount of load applied by this holder was adjusted. Also, to apply force in the vertical direction, four weights of 10, 20, 50, and 100 kg were used for 20 trials. In both manual dynamometer and load cell devices, the maximum force applied on them was shown as the number displayed in the note at the same time applying pressure on the force plate screen.

Considering the nature of the data and the normality of the data obtained by the K-S test, Pearson's correlation coefficient was used to check the validity of the information recorded by the force plate made by Danesh Salar Iranian Company with the manual dynamometer of the American Lafayette company and the load cell. Also, the internal consistency coefficient (ICC) was used to check the reliability of the power table [19]. All statistical analyses were analyzed using SPSS version 20 software at a significance level of $\alpha = 0.05$.

3. Results

Table 1 shows the validity between the maximum forces recorded by two force plate devices and a manual dynamometer in three directions. As can be seen, there is a significant and high relationship between the force sizes between the two devices in three directions: anterior-posterior (0.95), medial-lateral (0.96), and vertical (0.98).

Table 2 shows the validity between the maximum forces recorded by the two force plates and load cell devices in the anterior-posterior and medial-lateral directions. As can be seen, there is a significant and high relationship between the force sizes between the two devices in three directions: anterior-posterior (0.96), medial-lateral (0.96), and vertical (0.98).

Table 3 shows the average amount of maximum forces in 20 times of effort in three directions, anterior-posterior, medial-lateral, and vertical, along with the reliability coefficient between these 20 times of effort in three directions anterior-posterior, medial-lateral and vertical. As can be seen, the coefficient of internal similarity between 20 times of effort in three directions, anterior-posterior (0.96), medial-lateral (0.97), and vertical (0.98), is very high (excellent).

Table 1. Pearson's correlation test results to calculate the validity between two force plate devices and manual dynamometer in three directions anterior-posterior, medial-lateral and vertical

Device	Force direction	Mean±SD	R	*P*
Force plate (kg) Handheld dynamometer (kg)	Anterior-Posterior	30.85±1.4 31.1±1.5	0.95	0.001
Force plate (kg) Handheld dynamometer (kg)	Medial-lateral	29.9±1.1 30.1±1.8	0.96	0.001
Force plate (kg) Handheld dynamometer (kg)	Vertical	40±0.2 40.1±0.1	0.98	0.001

Table 2. Pearson's correlation test results to calculate the validity between two force plate and load cell devices in anterior-posterior and medial-lateral directions

Device	Force direction	Mean±SD	R	*P*
Force plate (kg)	Anterior-posterior	52.25±0.4	0.96	0.001
Load cell (kg)		52.3±0.5		
Force plate (kg)	Medial-lateral	53.8±0.2	0.96	0.001
Load cell (kg)		53.86±0.4		
Force plate (kg)	Vertical	70.55±0.2	0.98	0.001
Load cell (kg)		70.65±0.1		

Table 3. The results of the reliability test of the force plate device in 20 attempts in three directions: anterior-posterior, medial-lateral and vertical

Force Direction	Mean±SD	ICC (95%CI)
Anterior-posterior	71.32±1.3	0.96 (0.94-0.97)
Medial-lateral	68.71±1.1	0.97 (0.95-0.98)
Vertical	50 ±0.1	0.98 (0.96-0.99)

4. Discussion

This research aimed to investigate the validity and reliability of the Iranian force plate. The results of the Pearson correlation test showed a significant relationship between the results recorded by the Iranian force plate device and the dynamometer, as well as the results recorded by the load cell device in measuring force in the anterior-posterior, medial-lateral, and vertical directions ($P<0.05$).

The correlation coefficients (r) between the results of the Iranian force plate device and the manual dynamometer device in the anterior-posterior (0.95), medial-lateral (0.96), and vertical (0.98) directions can be observed in Tables 1 and 2. Similarly, the correlation coefficients between the results of the force plate device and the anterior-posterior (0.96), medial-lateral (0.96), and vertical (0.98) directions indicate a strong relationship between the two devices in measuring force, as suggested by the sources of this correlation coefficient [20].

Using accurate tools to measure variables is one of the necessities of research, and the validity of a device shows the nature of its measurement for the considered variable. According to the result, the force plate device manufactured by Danesh Salar Iranian Company can measure the force with the same accuracy as hand dynamometer and load cell devices, and researchers can trust the results of this tool.

In addition to having the device's validity, which is considered a necessity, having reliability is also important. Reliability is one of the essential features of a device to ensure the consistency and repeatability of the measurements made by that device. With increased reliability, the measurement error of the measuring device is reduced.

The results of the reliability test showed that the ICC of the force plate device manufactured by Danesh Salar Iranian Company in the three directions, anterior-posterior, medial-lateral and vertical, is equal to 0.96, 0.97 and 0.98, respectively (Table 3), high reliability 0.90 indicates good (high) reliability [20]. Due to this high reliability, it can be said that when the same

force is applied to the force plate, the sizes obtained from the force plate in different measurements will have the same results.

The high reliability of the force plate device makes it possible to use it with high reliability and repeatability in repeated research measurements with a large volume of samples where the amount of force applied to the force plate is measured by athletes at different times and many times. As a result, the measurement error is reduced, and the results can be interpreted with more confidence. This research, like other researches, has limitations, such as the use of a limited research sample and also the number of measurements regarding the evaluation of the reliability.

5. Conclusion

The high validity of the force plate device made by Iranian researchers shows the accuracy of the results in measuring the force applied to the device. The high reliability of the force plate device also shows the good reproducibility of the results of this device in repeated measurements, which is important in sports tests. it is suggested that researchers and experts in the field of sports can use this device in research due to the high validity and reliability of the force plate device manufactured by Danesh Salar Iranian Company and also the low price of the device compared to the foreign model.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors contributed to the original idea, study design.

Ethical considerations

The author has completely considered ethical issues, including informed consent, plagiarism, data fabrication, misconduct, and/or falsification, double publication and/or redundancy, submission, etc.

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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References

[1] Elliott B. "Biomechanics: an integral part of sport science and sport medicine". *Journal of Science and Medicine in Sport*. 1999; 2(4): 299-310. doi: 10.1016/s1440-2440(99)80003-6. PMID: 10710008.

[2] Li L. "How can sport biomechanics contribute to the advance of world record and best athletic performance?". *Measurement in Physical Education and Exercise Science*. 2012; 16(3): 194-202. doi: 10.1080/1091367X.2012.700802.

[3] Stefanyshyn DJ, Wannop JW. "Biomechanics research and sport equipment development". *Sports Engineering*. 2015; 18(4): 191-202. doi: 10.1007/s12283-015-0183-5.

[4] Yeadon M, Challis J. "The future of performance related sports biomechanics research". *Journal of Sports Sciences*. 1994; 12(1): 3-32. doi: 10.1080/02640419408732156. PMID: 8158746.

[5] Kamen G, Kinesiology E. *Research methods in biomechanics.* Champaign, IL, Human Kinetics Publ, 2004.

[6] Castro MP, Figueiredo MC, Abreu S, Sousa H, Machado L, Santos R, Vilas-Boas JP. "The influence of gait cadence on the ground reaction forces and plantar pressures during load carriage of young adults". *Applied Ergonomics.* 2015; 49: 41-46. doi: 10.1016/j.apergo.2015.01.004. PMID: 25766421.

[7] Hatze H. "Validity and reliability of methods for testing vertical jumping performance". *Journal*

of Applied Biomechanics. 1998; 14(2): 127-140. doi:10.1123/jab.14.2.127.

[8] Liu W, Nigg BM. "A mechanical model to determine the influence of masses and mass distribution on the impact force during running". *Journal of Biomechanics*. 2000; 33(2): 219-224. doi: 10.1016/s0021-9290(99)00151-7. PMID: 10653036.

[9] Novacheck TF. "The biomechanics of running". *Gait & Posture*. 1998; **7**(1): 77-95. doi: 10.1016/s0966-6362(97)00038-6. PMID: 10200378.

[10] Schot PK, Knutzen KM. "A biomechanical analysis of four sprint start positions". *Research Quarterly for Exercise and Sport*. 1992; 63(2): 137-147. doi: 10.1080/02701367.1992.10607573. PMID: 1585060.

[11] Shinohara Y, Maeda M. "The relation between block spacing and forces applied to starting blocks by a sprinter". *Journal of Japan Society of Sports Industry*. 2011; 21(2): 217-228. doi: 10.1016/j.proeng.2011.05.066.

[12] Bobbert MF, Mackay M, Schinkelshoek D, Huijing PA, van Ingen Schenau GJ. "Biomechanical analysis of drop and countermovement jumps". *European Journal of Applied Physiology and Occupational Physiology*. 1986; 54(6): 566-573. doi: 10.1007/BF00943342. PMID: 3948851.

[13] De Jesus K, de Jesus K, Abraldes JA, Medeiros AI, Fernandes RJ, Vilas-Boas JP. "Are the new starting block facilities beneficial for backstroke start performance?" *Journal of Sports Sciences*. 2016; 34(9): 871-877. doi: 10.1080/02640414.2015.1076166. PMID: 26252647.

[14] Mourão L, de Jesus K, Roesler H, Machado LJ, Fernandes RJ, Vilas-Boas JP, Vaz MA. "Effective swimmer's action during the grab start technique". *PLoS One*. 2015; 10(5): e0123001. doi: 10.1371/journal.pone.0123001.

[15] Cook DA, Beckman TJ. "Current concepts in validity and reliability for psychometric instruments: theory and application". *The American Journal of Medicine*. 2006; 119(2): 166. e7-166. e16. doi: 10.1016/j.amjmed.2005.10.036.PMID: 16443422.

[16] Drost EA. "Validity and reliability in social science research". *Education Research and Perspectives.* 2011; 38(1): 105-123.

[17] Martin H, Yule V, Syddall HE, Dennison EM, Cooper C, Aihie sayer A. "Is hand-held dynamometry useful for the measurement of quadriceps strength in older people? A comparison with the gold standard Biodex dynamometry". *Gerontology*. 2006; 52(3): 154-159. doi: 10.1159/000091824. PMID: 16645295.

[18] Mentiplay BF, Perraton LG, Bower KJ, Adair B, Pua YH, Williams GP, McGaw R, Clark RA. "Assessment of lower limb muscle strength and power using hand-held and fixed dynamometry: a reliability and validity study". *PloS One*. 2015; 10(10): e0140822. doi: 10.1371/journal.pone.0140822.

[19] Hopkins WG. "Measures of reliability in sports medicine and science". *Sports Medicine*. 2000; 30(1): 1-15. doi: 10.2165/00007256-200030010-00001.

[20] Muijs D. Doing Quantitative Research in Education with SPSS. McGraw-hill education (UK). 2013.