Viref Revista de Educación Física
Instituto Universitario de Educación Física y Deporte
ISSN 2322-9411 • Julio-Septiembre 2020 • Volumen 9 Número 3
UNIVERSIDAD DE ANTIOQUIA
1 8 0 3

Validity of the Dynamic Sensor in the medium speed in deep squat in multipower

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Summary

Objective: to observe the validity of the DynamicSensor with respect to the T-Force in the medium speed in deep squat in multipower. **Method**: the sample was 48 squats performed by 10 physically active male students. The measurement protocol consisted of performing 5 deep squats with a weight of 35kg at maximum concentric speed in a multipower machine in which the two instruments were installed. The average velocity of these measuring instruments was compared. **Results**: there were no statistically significant differences between both measurements (Mann-Whitney U> 0.05) and the correlation between both was very high and significant (Spearman's Rho = 0.969 and p <0.000). **Conclusion**: these statistical tests showed that the DynamicSensor is a valid and reliable instrument for measuring the average speed in deep squat in multipower.

Introduction

Several authors such as García et al. (2017), have used different instruments to measure important variables in sports training, including the speed of execution of the exercises. Balsalobre (2015), Balsalobre (2016), Bautista (2012), Bosquet et al. (2012), Campos et al. (2014), Comstock et al. (2011), González and Sánchez (2010), González et al. (2017a,b), Puga et al. (2012), Scott et al. (2016), have used force platforms and linear velocity transducers to observe variables that allow programming, control and evaluation of strength training in a much more precise way than traditionally used. On the other hand, authors such as Balsalobre et al. (2017), Comstock et al. (2011), Sato et al. (2009), Scott et al. (2016), have used wireless instruments either by smartphones or accelerometer applications, so it can be seen that there are several ways to measure speed of movement in strength training.

García et al. (2017), affirm that the most used instruments in speed measurements in sports training can be classified into linear speed and position transducers, optical position transducers, force dynamometer platforms, accelerometers (smartphones apps) and video analysis, also mentions that the linear speed transducers are the gold standard in the measurement of speed in sports training, their reliability and validity being very high. On the other hand, its disadvantages are the commercial value that ranges between 500 and 2500 euros, its assembly and connection is usually cumbersome, and the cable is very delicate.

The DynamicSensor is a low-cost prototype that aims to measure the speed of execution in sports movements, using an ultrasound sensor that is capable of recording distance and time. From these variables it is possible to obtain data of great importance for the programming, control and evaluation of sports training, such as the average speed, peak speed, accelerations and distances traveled. As above, it is very important to verify its validity with respect to the gold standard.

González (2012) affirms that it is necessary to decrease the time in the execution of movements if what is sought is to increase the performance; suggests considering the speed of execution in sports movements. When performing the sports movement by mobilizing the required loads of the sports specialty at the speed it demands, it guarantees a better performance. "Our goal is to improve it and we do not improve the performance if we are not able to improve this peak of speed by mobilizing the required loads, this is what we would call useful force" (González, 2012).

González & Gorostiaga (2002), affirm that a work that considers the speeds and the angles of execution of the sport movements, is a work well oriented to the useful force. The best reference point to apply with certainty the appropriate weight is the maximum speed of the movements, so we know the time to suspend the repetitions or decrease the weight to mobilize (González et al, 2017b).

In different studies conducted by González and Sánchez (2011), González et al. (2012), González-Badillo et al. (2017a,b) the strength training is related by relating the load and speed factors, in which it is concluded that, depending on the loads used, the speed of execution and that with the repetitions, speed is lost. When certain ranges of speed are lost it is convenient to suspend this exercise because it is possible to generate effects not related to the proposed objective.

González (2017a,b), states that the average propulsive speed of the first or fastest repetition before a weight, serves to estimate the relative intensity (% 1RM) that this weight represents at the moment. The above suggests that, knowing the speed in the first repetition with some load, it could be known if one is working in the percentage of RM programmed; also, knowing the maximum speed with any load, the new RM can be estimated.

Since the 90s technologies have been developed for the measurement of the speed of execution of sport movements, passing through the photoelectric cells of Tidow and ergopower of Bosco, to the point of developing wireless and easily portable methods such as wearables. All with different levels of precision, advantages and disadvantages for their technical characteristics (García et al., 2017). Table 1 shows the characteristics of the devices for measuring the speed of execution.

Table 1. Characteristics of the devices for the measurement of the speed of execution.

Type of device	Linear speed and position transducers (cable)	Optical position transducers (infrared)	Accelerometers (Smartphone apps)	Video analysis (Smartphone app)
Direct measurement (according to models)	vertical velocity (v), time (t), distance / spa (e)	time (t), distance / space (e)	3d accelerometers, time (t)	thanks to frames the distance, time (t), manual
Indirect measurement (depending on the models)	speed (e / t), force (m * a), acceleration (e / (t * t), v2-v1 / t2-t1; f / m), power (f * e / t)	speed (e / t), force (m * a), acceleration (e / (t * t), v2-v1 / t2-t1; f / m), power (f * e / t)	power (f * e / t), force (la), vertical speed, vertical acceleration	measurement speed (e / t2)
Sampling frequency (accordshowning to models)	200-1000 hz	500hz	50-200 hz	240 fps (hz)
Mechanical variables by software / app (depending on models)	medium / maximum acceleration, average / propulsive speed, maximum peak speed, speed, time, distance, by phases, time until reaching speed / power / force / maximum acceleration, prediction of rm (kg), loss of speed,	medium / maximum acceleration, average / propulsive speed, maximum peak speed, speed, time, distance, by phases, time until reaching speed / power / force / maximum acceleration, prediction of rm (kg), loss of speed,	strength (1rm), average / peak speed, average / peak power, total work (Kcal), prediction 1rm (kg)	average / peak speed, 1rm prediction (kg)
Advantages (depending on models)	measurement reliability (vs), data acquisition and analysis software, real-time feedback-feedback	measurement reliability (v), data acquisition and analysis software, real-time feedback-feedback,	affordability (250-300- €) portability, practicality, manageability, does not require calibration, registration-	affordability (€ 10- € 15), portability, practicality, manageability, does not record VMP or travel / displacement

Type of device	Linear speed and position transducers (cable)	Optical position transducers (infrared)	Accelerometers (Smartphone apps)	Video analysis (Smartphone app)
			feedback in real time	
Disadvantages and limitations (depending on model)	affordability (500-2500 €) assembly and connection (pc, interface, transducer), fragility of the cable, design to hook to the bar (and not to body segments), only for linear displacements,	calibrated connection to electrical network, assembly and connection (pc, interface, infrared camera, reflective, only for linear displacements	reliability and stability of the indirect measurements location of the sensor, only registration of the concentric phase, does not register VAM or travel / displacement, autonomy of the batte	reliability, indirect measurements, only linear displacements in concentric phase, feedback record is not in real time, position of the camera / mobile High-end smartphone with super slow camera
Trademarks (examples)	T-Force (spain), chronojump (spain), smartcoach (sweden), gymaware (australia) muscle lab (norway), ballistic measurement system (australia) globus real power (italy)	velowin (spain)	push-band (iOS), beast sensor (android; iOS), wiva power, atlas wristband, myotest	powerlift app (iOS), barsense (android, iOS)

Adapted from García et al. (2017).

Positive and negative characteristics of the devices available in the market for the measurement of speed in strength training (VPM = propelled measured speed, RFD = force production rate in the unit of time, N = Newtons, Hz = Hertz). Source: modified by García et al., 2017).

The speed and position transducers have a wire or cable from which a bar is connected. When the yarn is mobilized, the displaced length is recorded as a function of the time required for this, after which the rest of the parameters (strength, acceleration, power) are derived. These devices are linear therefore they need that the measured movement is also linear so that the data have reliability and precision. The latest devices include analysis and storage software that allows the observation in real time of important variables for the planning and regulation of training loads. The "optical" position transducers, they throw data every 2 ms by means of an infrared camera and in the same way as the linear transducers, they derive the other data of interest of the researcher or trainer. Due to the speed of data recording, the optical system is cataloged as a gold standard in the measurement of force (García et al., 2017).

The T-Force is a linear speed transducer that has a hardware (transducer + interface) and a software (computer program), which, in real time, allows an analysis of a series of repetitions, even allowing to analyze a single repetition and how the physical variables in them behave.

González et al. (2017a,b), affirms that the T-Force has the following characteristics:

- Direct measurement of travel speed
- 1000 hz frequency
- Does not require external power
- Small and transportable
- Error in the displacement calculation of +/- 1mm
- Error in the calculation of the speed <o = a 0,25%
- Supports 10 m / s in rise and 5 m / s in descent
- Supports 16 g of acceleration
- It has a distance of up to 2 meters
- The cable is tensioned at 5.3 N
- Optimal deviation of the cable with respect to the vertical is 2 ° or less
- The interface is a 14-bit resolution A / D converter
- USB 2.0 connection
- It works for Windows XP, VISTA, 7, 8 and 10.
- Exports data to Excel
- Auditory feedback for speed control
- Automatic detection of the best repetition of a series
- Has test mode and training mode

It can be connected with an FP-500 dynamometer platform for the synchronized measurement of force and speed.

The validation and reliability of the T-Force was made comparing the displacement of this device with a high precision digital caliber apparatus that was calibrated by the National Institute of Aerospace Technology. After comparing the measurements of 18 T-Force, the error in the speed was 0.25% and in the displacement of +/- 0.5 mm. We also performed 30 repetitions with two T Force at the same time (with speeds between 0.3 and 2.3 m / s) obtaining an ICC of 1.00 (95% CI: 1.00-1.00) and CV of 0.57 for the average propulsive speed. For the maximum speed the values were: ICC: of 1.00 (95% CI: 0.99-1.00) and CV of 1.75% (González, 2017a,b).

The portable technologies "without cables" also called Wearable have flooded the environment thanks to their strong advertising campaigns and their easy accessibility, since they only need a mobile app and, in some cases, a handle to be used. The information is analyzed from the Smartphone eliminating the need for a personal computer. They are Accelerometers and smartphones apps (Wearable technologies) which use the smartphone or bracelet type that has a small battery, have a triaxial accelerometer and a gyroscope, calculate the average speed by integration of the acceleration resulting from the three components ax, ay , az. On the other hand, there are Video-analysis and smartphones apps but that, in this case, the smartphones should be high technology since the camera's recording speed exceeds the usual speeds. The initial and final phase of the concentric phase is selected to calculate the time and derive the average speed with the help of the app, with the problems that the measurement is only reliable in one dimension and the data is not obtained in real time (García et al, 2017).

The DynamicSensor works thanks to an ultrasound, which measures the distance using sound waves. Emits an ultrasonic wave and receives the reflected wave that returns from the object, measuring the distance to the object counting the time between the emission and the reception; with the difference between the initial and final distance the displacement is obtained. Can calculate the average speed at which the movement is made by dividing by the time used to perform the movement. The sampling frequency is 50 hz and in wireless function it is powered by a 9v battery. For data transmission it is connected to the computer by bluetooth and also has the possibility of direct connection to the computer through wiring. The data obtained is exported to a spreadsheet and then manually operated in order to obtain the data you want to find from the distance traveled. Time used by attaching the mobilized load, just like the linear transducer.

Method

Investigative design

The type of study was exploratory, comparative, correlational, with transversal design and with a quantitative approach.

Population and sample

The population was conformed by the students of sport of the University San Buenaventura, and the sample was intentional, conformed by 10 physically active students (48 squats) of this university. The athletes signed the informed consent. The following criteria were taken into consideration: a) That they carried out gym training at least twice a week during the previous 3 months; b) That they signed the informed consent. The following were defined as exclusion criteria: a) Feel pain during the execution of the test; b) Voluntary withdrawal.

Variables

Average speed thrown by the Gold Standard T-Force instrument.

Average speed found with the DynamicSensor force measurement prototype.

Process

A regular warm-up was carried out, each of which was activated before starting its sporting activity, in a multipower machine loaded with 35 kilograms in the state in which the T-Force and the DynamicSensor were. In this way both teams measured the executions simultaneously (see image 1); each athlete performed 5 repetitions except one that performed 3 due to the presence of pain, which resulted in 96 data of average speed (48 of each instrument).

Figure 1. Data collection system Image. Photographs taken for the development of this research.

Bias Control

Measurement biases: The prototype did not have a start or stop auto, for this reason the data had to be manually trimmed to avoid differences in the measurement due to inopportune starts between the instruments. The tests were performed the same day and between tests a complete rest was provided.

Statistical analysis

The data was collected in Excel 2010 software, where the time, distance and average speed of each of the squats were considered as can be seen in table 2.

Results

Table 2. Time, distance and average speed of each of the squats.

Repetition	T-force			DynamicSensor		
	Time (s)	Distance (m)	Speed (m/s)	Time (s)	Distance (m)	Speed (m/s)
1	0,917	0,7076	0,7708	0,940	0,6748	0,7732
2	0,899	0,6958	0,7731	0,940	0,6597	0,7889
3	0,916	0,7065	0,7704	0,940	0,6687	0,7842
4	0,932	0,6940	0,7439	0,940	0,6626	0,7457
5	0,980	0,6825	0,6957	1,030	0,6552	0,6933
6	0,808	0,6401	0,7913	0,830	0,6108	0,7870
7	0,674	0,5677	0,8411	0,670	0,5290	0,8574
8	0,717	0,6130	0,8537	0,709	0,5752	0,8731
9	0,688	0,5925	0,8599	0,679	0,5571	0,8816
10	0,713	0,6366	0,8916	0,750	0,6041	0,8864
11	0,770	0,4952	0,6424	0,770	0,4691	0,6475
12	0,894	0,6144	0,6865	0,899	0,5831	0,7086
13	0,882	0,5805	0,6574	0,880	0,5515	0,6736
14	0,882	0,5869	0,6647	0,890	0,5549	0,6719
15	0,905	0,6058	0,6686	0,920	0,5769	0,6703
16	1,003	0,5999	0,5975	1,119	0,5806	0,5647
17	0,977	0,6762	0,6914	1,040	0,6479	0,6814
18	0,916	0,5513	0,6012	0,960	0,5261	0,5938
19	0,822	0,4720	0,5735	0,849	0,4498	0,5750
20	0,903	0,5297	0,5859	0,909	0,5041	0,5901
21	0,986	0,5705	0,5780	1,020	0,5518	0,5827
22	0,758	0,4924	0,6488	0,839	0,4808	0,6145
23	0,772	0,5423	0,7016	0,770	0,5206	0,7328
24	0,741	0,5061	0,6820	0,780	0,4856	0,6719
25	0,727	0,4866	0,6684	0,760	0,4671	0,6647
26	0,754	0,5063	0,6707	0,809	0,4908	0,6553
27	0,704	0,7431	1,0541	0,699	0,6935	1,0362
28	0,739	0,7904	1,0681	0,750	0,7353	1,0195
29	0,732	0,7859	1,0722	0,750	0,7320	1,0196

Repetition	T-force			DynamicSensor		
	Time (s)	Distance (m)	Speed (m/s)	Time (s)	Distance (m)	Speed (m/s)
30	0,763	0,8053	1,0540	0,760	0,7522	1,0113
31	0,798	0,8680	1,0864	0,840	0,8144	1,0011
32	0,735	0,5276	0,7169	0,869	0,5145	0,6414
33	0,693	0,5693	0,8204	0,689	0,5345	0,8372
34	0,700	0,5829	0,8316	0,699	0,5429	0,8324
35	0,724	0,5904	0,8144	0,729	0,5580	0,8134
36	0,734	0,5728	0,7793	0,750	0,5400	0,7759
37	0,803	0,6162	0,7664	0,839	0,5913	0,7641
38	0,674	0,7233	1,0716	0,699	0,6785	0,9957
39	0,703	0,7534	1,0702	0,719	0,7013	1,0247
40	0,701	0,7282	1,0374	0,729	0,6803	0,9834
41	0,747	0,7735	1,0341	0,740	0,7271	1,0394
42	0,758	0,7408	0,9761	0,790	0,6992	0,9585
43	0,715	0,7551	1,0546	0,729	0,7070	1,0095
44	0,716	0,7478	1,0430	0,729	0,7020	1,0043
45	0,724	0,7832	1,0803	0,750	0,7324	1,0094
46	0,672	0,6720	0,9985	0,699	0,6251	0,9514
47	0,710	0,7107	0,9996	0,729	0,6593	0,9662
48	0,775	0,7857	1,0125	0,810	0,7354	0,9563

The average velocity data of both instruments were analyzed by the Shapiro-Wilk statistic to determine the normality of their distribution. This statistic showed a significance of 0.001 and 0.005 respectively for the variables studied (Table 3), which indicated that the data thrown by the devices did not have a normal distribution.

Table 3. Shapiro-Wilk test for the average speed in the T-Force (TF) and in the DynamicSensor (DS).

Normality tests						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistical	gl	Sig.	Statistical	gl	Sig.
TF	0,151	48	0,008	0,897	48	0,001
DS	0,147	48	0,011	0,916	48	0,002

When finding a non-normal distribution, the Mann-Whitney U (Nonparametric statistics) was applied to determine if there were significant differences between the two sets of data and the Spearman test to establish if the data presented correlation. The results showed that there were no significant differences between the two tests and, furthermore, that their correlation was very high and significant (Table 4).

Table 4. Correlation Mann-Whitney U and Spearman.

Mann-Whitney U		**Spearman**	
Z	-0,659	Coeficient de correlation (r)	,969
Asymptotic Sig. (bilateral)	0,510	Asymptotic Sig. (bilateral)	0,000

Discussion

Although the sample was not large enough to generate conclusive data, the results obtained suggest the existence of a strong correlation (0.969), between the data thrown by both instruments of measurement, besides not finding significant difference between the measurements. It is suggested to continue testing the DynamicSensor to obtain more reliable conclusions with much larger samples.

Conclusions

With a significance of 0.510 in U of Mann-Whitney it is affirmed that the DynamicSensor does not have statistical differences with respect to the T-FORCE in the average speed taking in squat, and with a Spearman correlation coefficient of 0.969 and with a statistical significance of 0.000 it can be affirmed that the DynamicSensor measures in the same way the subjects that the T-Force. It is concluded that the DinamicSensor is valid and reliable to measure in medium speed in deep squat in multipower.

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