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Kinematical variables analysis of shot-put activity in para athletics (Class F32/33) and their relationships with digital level achievement.

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Abstract

Aim: The primary purpose of this part of was to Kinematical variables analysis of shot-put activity in Para-Athletics (Class F32/33) and their relationships with digital level achievement. **Methods:** International Paralympic athlete "Kerdjana Kamel" participated voluntarily in this study. He's the gold medalist and the record holder in this class F32/33 (Age: 37 years, Height: 1.76 m, Weight: 82 kg, Type of Impairment: cerebral palsy, origin of impairment: congenital, club: GSP Alger, Best Digital level: 12.24 m). The analysis of the present study was doing with the software Kinovea software 0.8.15 for the kinematical analysis, we used two cameras (AEE. 120ips, 1280*720, 720p) for record the Kinematic performance during the first and second phase (Start and Finish Pushing) in the Shot-Put. sites of this cameras (Cam; X0.5m, Y1.5m. Cam; X6m, Y5.5m). Shot-Put tries were applied for our sample (the international Paralympic athlete) in eight tries, we choose the best six tries for analysis. The data were analyzed in SPSS program, descriptive statistics (mean±Sd, Std.E) and Pearson test for the correlations between variables.

Results: As a result of the statistical analysis, there was a positive significant correlations of the Digital level with Distance of shot from the armrest (0.04*), and with The wrist Angle of the shooting hand (0.015*) in the first phase (start pushing), and in the second phase (finish pushing) there was a negative significant correlations of the Digital level with Pushing angle (-0.013*) , and Positive significant correlations with Shot height (0.006**).

Conclusion: Based on the kinetic Performance results analysis of Paralympic elite (the Shot-Put Activity, Class 32/33) in practice; we confirm: 1) The increase in the variables values of Distance shot from the armrest, and the wrist Angle of the shooting hand in first phase of pushing (start) are affects the digital level achievement, Also the Shot height variable in the second phase of pushing, 2) The decrease in the value of Pushing angle variable in second phase of pushing (finish) is affect the digital level achievement.

Keywords

Kinematical variables,
Para athletics,
Shot-put,
Digital level,

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INTRODUCTION

Biomechanics is the main field of objective research into the technical rules and methods of various kinetic skills (Guebli, Regiueg, et al., 2018). This is affected through precise measurements that are processed quantitatively by the laws of physics (R. Bartlett, 2007; Zerf Mohammed et al., 2015). There is no doubt that the objective study of any skill contributes to the development of the scientific foundations of the participant in terms of their ability to innovate and reach the best performance level possible (Elbadry et al., 2019). Biomechanical Knowledge is a "Must" for Coaching. All movements of Athletes are determined by the laws of mechanics. It is the first task of science (but only the first) to understand movements of athletes; therefore, it is an indispensable base for understand the basics of Performance kinetic in different activity and for coaching. In the throwing events the factors influencing the performance are classified into: 1. the physical laws of the flight phases of the implement and; 2. the biomechanical laws of the movement of the system 'thrower and implement' before release (SUGUMAR.C, 2012). Video analysis is a great system that films one's performance and reconstructs a model of one. Athletes can then compare one's technique on a good day and a bad day, athlete can compare one's technique with an expert (if one are not already), and much, much more (Franks & Goodman, 1986).

Paralympic Games is a multi-sport event for athletes with physical, mental and sensorial disabilities. This includes mobility disabilities, amputees, visual disabilities and those with cerebral

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palsy (Brittain, 2016). The Paralympic Games are held every four years, following the Olympic Games, and are governed by the International Paralympic Committee IPC (International Paralympic Committee 2018). The Paralympic Games is the highest obtainable level for all athletes. Evidence based classification in Paralympic Sport requires evidence for the impact of the underlying impairment on sport specific performance (Webborn, 2009). During Rio 2016 Paralympic Games, 4350 athletes from more than 160 countries participated in these games for 528 males from different sports (Van Biesen et al., 2018). In para athletics open to athletes in various disability groups, based on a functional classification system, which is coordinated by world para athletics sports technical committee (van Dijk et al., 2017). Algeria achieved new Gold medals in the male competitions for elite throwers with impairment of cerebral palsy (Class F32/33). The level of competition was of high quality, where Performing well in shot-put consists of simply throwing the shot as far as possible (Landolsi et al., 2018).

Kinematic analyses of the throwing techniques of elite stationary shot-putters are commonly conducted in routine observations and sport research (Ariel et al., 2005). Some of these analyses focused on parameters underlining either the sequence of actions taken by the athlete leading to the release of the shot (e.g. spatial and temporal characteristics of backward and forward thrust, range of motion, linear and angular momentum of each segment) or the shot's trajectory at the instant of release (e.g. position, speed and angle of shot) (John W. Chow et al., 2000; O'Riordan & Frossard, 2006). To the best of our knowledge, most research has focused on biomechanical variables of the para-athletics and studied the effects, comparative and correlation of kinetic and kinematics variables with digital level (Guebli, Bessenouci, et al., 2018), in athletics disciplines such as the Shot-Put throw (Abdelkader et al., 2018a; Błażkiewicz et al., 2019; Gilberto, n.d.; Hubbard et al., 2001; Landolsi et al., 2018; Lee et al., 2015; Willwacher et al., 2011), Discus Throw (Abdelkader et al., 2018a; R. M. Bartlett, 1992; Błażkiewicz et al., 2019; J. W. Chow & Mindock, 1999; Delgado, 2012; Hay & Yu, 1995; Leigh et al., 2010; Maroński, 1991; Shestakov, 2005). Some of these analyses focused on parameters underlining either the sequence of actions taken by the athlete leading to the release of the throw (e.g. spatial and temporal characteristics of backward and forward thrust, range of motion, linear and angular momentum of each segment) or the throw's trajectory at the instant of release (e.g. position, speed and angle of throw) (L. Frossard et al., 2007).

These studies contributed to improvement of training programs of stationary throwers as they provided coaches and athletes with a better understanding of throwing technique as well as strength and fitness requirements (O'Riordan & Frossard, 2006), along with the long-term development of very complex skills, and the abil-ity to perform these complex and precisely timed movements at high velocity in a confined space (i.e. technique) (Marcos Gutiérrez-Davila et al., 2009; SUGUMAR.C, 2012), Where G. Davila reported that the shot-put technique is individual; each thrower uses his or her own individual temporal sequence and rhythm. Apart from the body composition and strength of the thrower, also the degree of automation of the individual temporal sequence determines the optimal individual technique (John W. Chow et al., 2000; Marcos Gutiérrez-Davila et al., 2009). however, it remains currently unknown whether the observed differences in performance are due to: intrinsic factors of the throwers (e.g. body composition, strength), external factors (e.g. training volume, quality of the coaches), their underlying cognitive impairment, or a combination of multiple factors (L. Frossard et al., 2007) or the characteristics of kinetic performance in Shot Put Activity in Paralympic Athletcs.

Thus, the present study aimed at Continue the work initiated by Guebli et al, 2017 by reporting the parameters of the shot's trajectory for male gold medal during world-class events, and analyzing the kinetic performance in different Para-athletics class in this activity. Also, to provide the magnitude of differences in these parameters across classes and genders. Therefore, the primary purpose of this part of was to Kinematical variables analysis of shot-put activity in para-athletics (Class F32/33) and their relationships with the digital level achievement.

METHOD

Participants

International paralympic athlet "Kerdjana Kamel" participated voluntarily in this study. The participant is the gold medalist and the record holder in this class F32/33. Kerdjana Kamel (Age: 37 years, Height:

1.76 m, Weight: 82 kg, Type of Impairment: celebral pallsy, origin of impairment: congenital, club: GSP Alger, Best Digital level: 12.24 m).

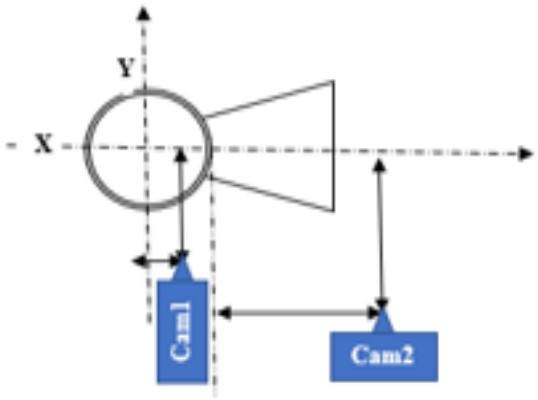
Ethics Committee approval of this study was obtained from Laboratory APS, Society, Education and Health, Faculty of Physical Education and Sports, Hassiba Benboualy University of Chlef, doctorat project Committee (2016/ biomechanics of Physical Activities and Sport).

Research Design: For the purposes of analysis, we have calculated the distance of the Shot-Put in two-dimensional. The analysis of the present study was with the software Kinovea, the capture and measured distance of each phase of Shot-Put as Fig.1. Sites of the two cameras that depicting the distance Shot-put These cameras (AEE MagicCam, 170° view, MOV Format Video, 720p Video Resolution, 120 ips NTFS, Screen Resolution 1280*720 16:9).

Were placed at distances of X0.5 m and X6 m from the midline of shot-Put circle, with their optical axes at right angles to this line. The first camera was placed Y1.5 m forward (or on the circle side) from the axis of the circle and was used to record the Kinematic performance during the first and second phase (Start and Finish Pushing) of the Shot-Put.

The second camera was placed Y5.5 m forward of the front edge of the board and was used to record performance during the second phase in Shot-Put. To measure the real distance, a series of markers was placed in carefully measured locations along the inside. These markers served as reference measurement. Shot-Put tries were applied for our sample (the international paralympic athlete) in eight tries, we choos the best six tries for analysis.

Fig 1. The method chosen to Capture Video of the variables in Shot-Put Performance.



Kinematic Variables: Based in the similar studies, we choose the kinematic variables for analysing the performance kinematic of athlete in shot-put activity class F32/33 in two phase, the first phase of start pushing (variables; The number of swings, Standby time, Time of push, Distance of shot from the armrest, Trunk angle, Cubitus Angle of the shooting hand, Shoulder angle of the shooting hand, The wrist Angle of the shooting hand, Cubitus Angle of the Support hand, Shoulder angle of the Support hand, Distance of shot from the neck), and in the second phase of finish pushing (variables; Digital level, Trunk angle, Cubitus Angle of the shooting hand, Shoulder angle of the shooting hand, The wrist Angle of the shooting hand, Pushing angle, Shot height, Max height of shot, Time of Throwing, Total Performance Time).

We used kinovea softwore 0.8.15 for the kinematical analysis, it's a video player for sport analysis. It provides a set of tools to capture, slow down, study, compare, annotate and measure technical performances.

Data Collection

Our cameras were attached to our laptops to record directly into folders prepare in advance for each attempt chosen for analysis. The distances of the analysis's tests are shown in Table 1 for the athlete of Algerian Paralympic elite. With the software Kinovea, the films obtained for each try were phase analysis for each variable and try.

Statistical analysis

The data analysis procedures used in this study consisted of the computation of the means, standard deviations (SD), standard deviation Error (Std.E) as descriptive statistics, and the Pearson test for the correlations between all variables identified in based of similar studies. Statistical results were analyzed at ($p<0.05$) and ($p<0.01$) significance levels.

We used SPSS (SPSS for Windows, version 22.0, SPSS Inc. Chicago, Illinois, USA) statistical program for that statistical analysis of the data obtained.

RESULTS

Table 1. Description Results of the Algerian world Champion of Shot-Put Class F32/33 "Kerdjana Kamel" in the kinematic analysis of his Performance.

Variables	Mean±Sd	Std. E	Min/Max	Mean±Sd	Std. E	Min/Max
		Stage I			Stage II	
Digital level (m).	10.423±0.015	0.006	09.40/10.44	10.423±0.015	0.006	09.40/10.44
The number of swings	3.166±0.408	0.166	3.00/4.00			
Standby time (s)	2.285±0.015	0.006	2.27/2.31		----	
Time of push (s)	0.305±0.005	0.002	0.30/0.31			
Distance of shot from the armrest(cm)	51.253±0.017	0.007	51.23/51.28			
Trunk angle (°)	62.333±0.816	0.333	61.00/63.00	86.166±0.408	0.166	86.00/87.00
Cubitus Angle of the shooting hand(°)	16.333±0.816	0.333	15.00/17.00	154.666±0.816	0.333	154.00/156.00
Shoulder angle of the shooting hand (°)	24.000±0.894	0.365	23.00/25.00	160.833±1.834	0.749	159.00/163.00
The wrist Angle of the shooting hand(°)	108.166±1.329	0.542	106.00/109.00	155.166±0.983	0.401	154.00/156.00
Cubitus Angle of the Support hand (°)	116.500±1.048	0.428	115.00/118.00			
Shoulder angle of the Support hand (°)	56.000±2.00	0.816	54.00/59.000		----	
Distance of shot from the neck (cm)	12.096±0.030	0.012	12.05/12.130			
Pushing angle (°)				50.500±1.048	0.428	49.00/52.00
Shot height (cm)				202.785±.815	0.333	201.12/203.16
Max height of shot(cm)		----		399.468±1.480	0.604	397.66/401.26
Time of Throwing (s)				1.658±.018	0.007	1.64/1.68
Total Performance Time (s)				4.248±0.027	0.011	4.22/4.28

Table 1 shows the description results of performance kinematic Analysis for our sample "Kerajaan Kamel" (the Algerian world Champion, Class F32/33) in Shot-Put activity during the first and second stage of performance (start & finish pushing), the results explaine the values of mean±Sd, Std.Error, Minimal and maximal Values of variables.

Table 2. The connectivity relationships between variables in order to study in stages of performance (I and II).

The Variables correlated Stage I		Sig. p	The Variables correlated Stage II		Sig. p
Digital level	Distance of shot from the armrest	0.832* 0.040	Digital level	Pushing angle	-0.907* 0.013
	The wrist Angle of the shooting hand	0.898* 0.015		Shot height	0.935** 0.006
Time of push	Distance of shot from the armrest	-0.891* 0.017	Shot height	Pushing angle	-0.813* 0.049
	Shoulder angle of the Support hand	-0.905* 0.013	Max height of shot	Cubitus angle of the shooting hand	0.845* 0.034
Shoulder angle of the Support hand	Distance of shot from the armrest	0.985** 0.000	The wrist Angle of the shooting hand	Shoulder angle of the shooting hand	0.953** 0.003
Distance of shot from the neck	Trunk angle	-0.820* 0.046	Total Performance Time	Time of Throwing	0.818* 0.047
The Variables correlated between Stage I & Stage II					
Pushing angle	Time of push	0.905* .0130	Cubitus Angle of the shooting hand II	Cubitus Angle of the shooting hand I	-0.850* 0.032
	Distance of shot from the armrest	-0.985** .0000		Shoulder angle of the shooting hand I	0.839* 0.037
	Shoulder angle of the Support hand	-0.955** .0030		Cubitus Angle of the Support hand	0.953** 0.003
Shot height	The wrist angle of the shooting hand	0.826* 0.043	Time of Throwing	Standby time	0.818* 0.047
The wrist Angle of the shooting hand II	Shoulder angle of the shooting hand I	0.904* 0.013	Max height of shot	Cubitus angle of the shooting hand I	-0.939** 0.005

(*p<0.05*)* Correlation is significant at the 0.05 level.
(*p<0.01*)** Correlation is significant at the 0.01 level (*1-tailed*).

Table 2; shows the correlation results between kinematic variables for our sample in the first stage of Shot-put (start pushing), in the second stage (finish pushing), also between kinematic variables of first and second stage in shot-put. The significant correlation was observed at the 0.01 & 0.05 level (1-tailed) and degrees of freedom (n-1) between the values of kinetic performance in the first stage (start pushing), the correlations are positive significant in; the Digital level with Distance of shot from the armrest (0.040*), and with the wrist Angle of the shooting hand (0.015*) at the 0.05 level. Also, between the Shoulder angle of the Support hand with Distance of shot from the armrest (0.000**) at the 0.01 level. The correlations are negative significant in; Time of push with Distance of shot from the armrest (-0.017*), and with Shoulder angle of the Support hand (-0.013*), also between Distance of shot from the neck and Trunk angle (-0.046*) at the 0.05 level.

The significant correlation was observed at the 0.01 & 0.05 level (1-tailed) and degrees of freedom (n-1) between the values of kinetic performance in the second stage (finish pushing), the correlations are positive significant in; Max height of shot with the Cubitus angle of the shooting hand (0.034*), and Total Performance Time with the Time of Throwing (0.047*) at the 0.05 level. Also, between the Digital level with Shot height (0.006**), and between the wrist Angle of the shooting hand with the Shoulder angle of the shooting hand (0.003**) at the 0.01 level. The correlations are negative significant in the Digital level with Pushing angle (-0.013*) at the 0.05 level, and Positive significant with Shot height (0.006**) at the 0.01 level.

The significant correlation was observed at the 0.01 & 0.05 level (1-tailed) and degrees of freedom (n-1) between the values of kinetic performance in the first and second stage (start and finish pushing), the correlations are positive significant in; Pushing angle with Time of push (0.013*), and Shot height with The wrist angle of the shooting hand (0.043*), and The wrist Angle of the shooting hand Π with Shoulder angle of the shooting hand I (0.013*), and the Cubitus Angle of the shooting hand Π with Shoulder angle of the shooting hand I (0.037*), and the Time of Throwing with Standby time (0.047*) at the 0.05 level, and between the Cubitus Angle of the shooting hand Π with Cubitus Angle of the Support hand (0.003**) at the 0.01 level. The correlations are negative significant in; Cubitus Angle of the shooting hand Π with Cubitus Angle of the shooting hand I (-0.032*) at the 0.05 level, also, between the Max height of shot with Cubitus angle of the shooting hand I (-0.005**), and Pushing angle with Distance of shot from the armrest (-0.000**) and with Shoulder angle of the Support hand (-0.003**) at the 0.01 level.

DISCUSSION

The goal of this study was to the Kinematical variables' analysis of shot-put activity in Para-Athletics (Class F32/33) and their relationships with digital level achievement. The results indicated that the correlation values of Variables; Distance of shot from the armrest, the wrist Angle of the shooting hand (start pushing), and the Shot height, pushing angle (finish pushing) were significant with the digital level achievement. from that, also we can see the significant correlation values of Variables; Distance of shot from the armrest with the Shoulder angle of the Support hand, and the Pushing angle. also, the wrist Angle of the shooting hand with the Shoulder angle of the shooting hand, and Shot height. also, the Pushing angle with Shot height with Time of push, and Distance of shot from the armrest, and with the Shoulder angle of the Support hand. These kinematic variables in the performance of our sample, were important for effective and supportive for basics variables correlated to digital level achievement.

According to Biomechanical & Performance researches, a most basic kinematic variables effective in shot putting techniques of disability male athletes, with a result in reduction of the acceleration path of the shot resulting in a lower speed of the shot at release (Abdelkader et al., 2018b). the digital level and pushing angle are inversely related. As one parameter increases, the other decreases. Pushing angle can be manipulated depending on the throwers strength and anthropometrics (Cooper & Luigi, 2014). Projectiles obey constant acceleration, making them easier to describe and understand (Galileo's equations). Three factors deter -mine trajectory, including horizontal displacement, of a projectile: speed of release, angle of release, height of release (Maroński, 1991). The goal is to determine the pushing angle that optimizes the total distance for the release velocity attained for the thrower. For the shot put, the optimum angle of release is between 31° and 36° (SUGUMAR.C, 2012), Positive height of release, optimal angle should be slightly lower than 45°. Theoretically optimal angle is about 40-41°. Skilled

shot-putters use angles of 35-37° (Judge et al., 2016). The mathematically calculated optimal release angle αopt ranges from 40° to 43° and is calculated by the following formula (Milan coh et al., 2008):

$$\alpha_{opt} = \frac{1}{2}\arccos\left(\frac{1}{1+\frac{v_R^2}{gh_R}}\right)$$

but in the present study indicates that the shot-putter has achieve distance of 10.423 ±0.015 meters. Shot-putter use angles of Push are 49°-52°. All athletes have their own specific optimum Pushing angle because of individual differences in the rate of force generation and apply and the Disability classification (Keogh & Burkett, 2013). where, the study results may depend upon the factors related to shot put performance, Lowest and highest shot-put performance depends upon the angle of release. To achieve good performances, it is not necessary to throw at very close to the optimum release angle. Throwing with a high release speed is more important to performance than throwing at the optimum release angle (L. A. Frossard et al., 2005; Perrin et al., 2000).

As expected, these results confirm the findings of previous studies focusing two predominant factors, The velocity and angle to the performance of gold medalists (Abdelkader et al., 2018b). The lack of strong relationship with the position at release might be explained by the difference in Shot height was since all the throwing frames have the same height of 75cm, corresponding to the maximum height allowed by the IPC's rule (L. Frossard et al., 2007). The main mechanisms explained for that performance analysis are the Technique acquisition might be one major factor which is restricted by a cerebral palsy disability (Kohe & Peters, 2016).

However, it is likely that the performance relied more importantly on the throwing technique and functional outcome as they are both directly related to velocity and angle of release. Shot-putting requires great explosive strength, together with the ability to perform precisely timed movements in a confined space(Landolsi et al., 2018). The athlete's objective is to project the shot as far as possible, but competition regulations restrict the technique that may be used. The shot must be thrown from the shoulder using one hand and it must be held near to the chin throughout any preliminary movements (Błażkiewicz et al., 2016).

In the end, sport scientists, coaches, athletes and classifiers can only rely partially on data provided in the literature for a sound understanding of the current performance of medalist stationary shot-putters (L. A. Frossard et al., 2005). As pointed out by Chow 2000, "More quantitative data, especially those collected during major competitions, are needed for the development of a data base on performance characteristics" (John W. Chow et al., 2000). Anyone with a serious interest in the performance of top-level athletes should appreciate the importance of the smallest worthwhile change in performance, the change that makes a meaningful difference to an athlete's chances of winning. Also, knowledge of this change is needed when assessing athletes with a performance test either to make decisions about meaningful changes in an individual or to re-search strategies that might affect performance.

CONCLUSION

As a results of kinetic Performance analysis of Paralympic elite (the Shot-Put Activity, Class 32/33) in practice; we confirm: 1) The increase in the variables values of Distance shot from the armrest, and the wrist Angle of the shooting hand in first phase of pushing (start) are affects the digital level achievement, Also the Shot height variable in the second phase of pushing, 2) The decrease in the value of Pushing angle variable in second phase of pushing (finish) is affect the digital level achievement.

PRACTICAL APPLICATION

The kinematical analysis of performance is very importenet for achinement the the digital level, for that, we need to focus on applying biomechanical principles to during kinetic performance, Also Ensure that the required mechanical position is taken at every stage of performance and in line with the kinetic

performance requirements. Especially for the Paralympic athletes due to their physical and kinetical characteristics, depending on the nature and classification of their disability.

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