KINEMATIC VARIABLES ANALYSIS OF DISCUS THROW ACTIVITY IN PARA-ATHLETICS (CLASS F57) AND THEIR RELATIONSHIPS WITH DIGITAL LEVEL ACHIEVEMENT. PART I.

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Abstract: The aim of this study is to analyze kinematical variables of discus throw activity in Para-Athletics F57 and to investigate their relationships with digital level achievement. International Para-athlete "Saifi Nassima" participated voluntarily in this study. The athlete threw the discus with her right arm. Recordings were made by synching cameras (AEE MagicCam, 170° view, MOV Format Video, 720p Video Resolution, 120 ips NTFS, Screen Resolution 1280*720 16:9) for side and rear views by a LANC (CONTROL-L) device. The athlete wore reflective markers to track their motions on joints of the wrists, the elbows, the shoulders, the hip center, and down the neck with the least possible number of occlusions, to analyze the length and angle of movement by the x and y axis. The best six throws during the first and second phases (start and finish throwing) of the discus throw were included for analysis in two-dimensional by Dartfish.9 software. Means, standard deviations, minimum and maximum values were applied as descriptive statistics, and Pearson test for the correlations between all variables. As a result, there was a positive significant correlation of digital level with cubitus angle of the throwing hand (p< .001), trunk angle (p< .005) in the first phase, and with disk flight time (p< .005), throwing angle (p< .001) in the second phase. In conclusion, we confirm that the increase in the values of the variables of distance shot from the armrest, and the wrist angle of the shooting hand in the first phase of throwing, affects the digital level achievement. The decrease in the value of the throwing angle variable in the second phase of throwing affects the digital level achievement.

Keywords: Kinematical variables, para-athletics, discus throw, digital level.

PARA-ATHLETICS (SINIF F57) DISK ATMA AKTİVİTESİNİN KINEMATİK DEĞİŞKENLERİNIN ANALİZİ VE DIJİTAL SEVIYE BAŞARISI İLE İLİŞKİLERİ. BÖLÜM I.

Öz: Bu çalışmanın amacı, Para-Athletics F57'de disk atma etkinliğinin kinematik değişkenlerini analiz etmek ve bunların dijital seviye başarısı ile ilişkilerini araştırmaktır. Uluslararası Para-atlet "Saifi Nassima" bu çalışmaya görevli olarak katıldı. Sporcu diski sağ koluya fırlattı. Kayıtlar, bir LANC (CONTROL-L) cihazı ile yan ve arka görünürler için kameralar (AEE MagicCam, 170° görünüm, MOV Format Video, 720p Video Çözünürlüğü, 120 ips NTFS, Ekran Çözünürlüğü 1280*720 16:9) senkronize edilerek yapılmıştır. Sporcu, x ve y eksenleri için hareketin uzunluğunu ve açısal analiz etmek için mümkün olan en az sayıda okluzyonla bilekler, direkler, omuzlar, kalça merkezi ve boyundaki eklemlerdeki hareketleri izlemek için yanüstü işaretlere takı. Ekseni. Disk atışının birinci ve ikinci aşamalarındaki (başlangıç ve bitiş atışları) en iyi altı atış Dartfish.9 yazılımı ile iki boyutlu olarak analize dahil edilmiştir. Tanımlayıcı istatistik olarak ortalamalar, standart sapmalar, minimum ve maksimum değerler, tüm değişkenlerarasındaki korelasyonlar için Pearson testi uygulandı. Sonuç olarak, dijital seviye ile fırlatan elin kübitus açısı (p< .001), birinci aşamada gövde açısı (p< .005) ve disk uçuş süresi (p< .005) ile pozitif ve anlamlı bir korelasyon bulundu, ), ikinci aşamada atış açısı (p< .001). Sonuç olarak, atışın ilk aşamasında koltaklan atış mesafesi ve atış yapan elin bilek açışı değişkenlerin değerlerindeki artışın dijital seviye başarısını etkilediğini doğruladık. Fırlatmanın ikinci aşamasında fırlatma açısı değişkeninin değerindeki azalma, dijital düzeydeki başarıyı etkiler.

Anahtar Kelimeler: Kinematik değişkenler, para-atletizm, disk atma, dijital seviye

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INTRODUCTION

Paralympic games are a multi-sport event for athletes with physical, mental, and sensorial disabilities. This includes mobility disabilities, amputees, visual disabilities and those with cerebral palsy (Brittain, 2016). Discus throw is one of the oldest sports in athletics. It is one of the four throwing events in track and field (Hay and Yu, 1995). Complicated movements performed at high speed in a limited space make the discus throw technically and physically very demanding (R. M. Bartlett, 1992). The technically and physically demanding nature of the discus throw requires thorough biomechanical studies to have a good understanding of the techniques and training of elite discus throwers (Dapena, 1994). It has been studied for a long time by coaches, scientists and biomechanics experts. Biomechanics is the main field of objective research into the technical rules and methods of various kinetic skills (Guebli, Reguieg, et al., 2018). Kinematic analyses of the throwing techniques of elite stationary discus throwers are commonly conducted in routine observations and sport research (Guebli Abdelkader et al., 2018). Therefore, biomechanical knowledge is a “must” for coaching (Abdelkader et al., 2021; Arguz et al., 2021). All movements of athletes are determined by the laws of mechanics. Few studies involving discus throw (especially in disabled athletes) describe the forces which act on discus flight phase. It may be caused by minor release velocity and flight time, short trajectory so that it decreases the effects of aerodynamic forces on the disabled thrower (Banja, 2007; Frohlich, 1981; Yu et al., 2002). These studies have contributed to the 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 and Frossard, 2006). However, a recent extensive review of literature revealed that although there are many debates on different aspects of the techniques of throwing the discus, the biomechanical studies on this topic for the Paralympians athletes are very limited (Abdelkader, Madani, Adel, et al., 2018; R. M. Bartlett, 1992; Dai et al., 2013; Frossard et al., 2013a; Guebli et al., 2020; Leigh et al., 2010).

The primary reason for the lack of biomechanical studies appears to be due to the complexity of the technique of throwing the discus (Hubbard and Cheng, 2007) for Paralympic athletes. The lack of biomechanical studies on discus throwing (Paralympic) techniques has limited coaches’ and athletes’ understanding of the techniques and appropriate physical and technique training for performance improvement especially in disabled athletes. It may be caused by the different phases of discus throwing between different athlete’s class (Martins Freire et al., 2017; Morriën et al., 2017). Discus throwing is generally divided in five phases; preparation, entry, airborne, transition and delivery (R. Bartlett, 2000; Yu et al., 2002). But this is different for seated throwers of class 57; the performance of elite seated throwers depends on the interaction between the design of the athletes’ throwing frame and their throwing technique (Auriemma and De Luigi, 2018). Most frames feature up to four legs, foot rests, and strapping systems to anchor the athlete to the seat and the frame to the ground. The typical seat area is composed of a flat surface with some form of cushioning that must be no higher than 75 cm from the ground. Athletes are also allowed to use a back-rest, and a pole at their discretion for balance purposes and/or to generate driving forces (Frossard et al., 2005). Thus, the throwing phases may be limited for the seated throwers of class 57 in preparation phase (straddle position, established posture, recovery pre-stretch), preliminary movement or entry phase (> body mid-line twist), power position / delivery or transition phase (max. T-spine/shoulder flexibility, min. Torso tilt, max. Implement radius), and delivery / recovery phase (maintained posture, established block, max. Implement radius, > body mid-line release) (Green, 2012). And these are one of the most likelihood reasons that complicate these studies during analyzing the motor performance aspects in disabled athletes (Abdelkader et al., 2020). Based on our theoretical vision, the analysis of the entire seated throw (firm seat cushion, firm strapping, foot plates, holding bar)

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was subdivided into the following functional phases: 1. Preparation: from the first extension in swing of the throwing hand until the start of entry (athlete will either twist or tilt or twist/tilt torso). 2. Entry: from the maximal extension of the throwing hand during the last swing until the start of transition (best possible body position to execute the delivery phase of the throw). 3. Transition: from last maximal extension of the throwing hand during the last swing until the end of the throw extension in last swing (actual beginning of the throw for create force, and only upper body movements). 4. Delivery: from end of transition until the last picture the hand is in contact with the discus.

Therefore, the present study is an attempt to continue the work initiated by Guebli A et al., 2017 through reporting the parameters of the discus trajectory for female gold medal during world-class events, and analyzing the kinetic performance in different Para-athletics classes in this activity. It provides the magnitude of differences in these parameters across classes and genders. As such, the purpose of this paper is to analyze the kinematical variables of discus throw activity in Para-Athletics (Class F57) and their relationships with digital level achievement by an international champion disabled athlete. Hence, the researcher in this study hypothesized that there are kinematical variables in the kinetic performance that influence the level of digital achievement due to the indications of statistical relationships with the digital level achievement.

**METHOD**

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).

**Sample size:** International Paralympic athlete "Saifi Nassima" participated voluntarily in this study. The athlete is two times gold medalist in Paralympic games and three times world champion. Also, she is the world record holder in discus throw class F57. Saifi Nassima (age: 30 years, height: 1.80 m, weight: 88 kg, type of impairment: limb deficiency, origin of impairment: acquired, club: GSP Alger, best digital level: 34.31 m) (Nassima Saifi - Athletics | Paralympic Athlete Profile, 2019).

**Research Design:** For the purposes of analysis, we have calculated the distance of the discus throw in two-dimensional (2D). The athlete threw the discus with her right arm. Eight attempts of the athlete were recorded and only the best six throws were included in the final analysis. During data collection, recordings were made with two cameras (AEE MagicCam, 170° view, MOV Format Video, 720p Video Resolution, 120 ips NTFS, Screen Resolution 1280*720 16:9) where the angle between the optical axes of the two cameras was 90°. The cameras 1 and 2 were placed at distances of 2.8 m on both sides of the throwing circle (side view, rear view) from the thrower and were used to record the kinematic performance during the first and second phases (start and finish throwing) of the discus throw. These two phases (start and finish throwing) in our study were chosen based on the performance characteristics of the Para-athletes class F57 in discus throwing. The analysis of the entire throw in this study was subdivided into the following functional phases: 1. start throwing (entry): from the maximal extension of the throwing hand during the swing until the start of transition. 2. finish throwing (delivery): from end of transition until the last picture; the hand is in contact with the discus. For synching the cameras, all start buttons were linked together electrically by a LANC (CONTROL-L) device to computer (100 Hz). Since the device requires LANC inputs on camcorders or ACC inputs on still cameras, it can be used on some camcorders. Then, the throws were manually synched. The longest official distance thrown was recorded using a
separate camera that was placed at distances of x15 m*y12.5 m from forward of the front edge of the board. All cameras were positioned at y1.5 m in height. To measure the real distance, a series of markers were placed in carefully measured locations along the inside with axes x, y, z 2.25 m reference scaling frame, and the calibration was based on eight reference points for the two cameras (side view, rear view). And four markers were placed along the throwing location on the ground with a x1 m reference scaling for the separate camera. These markers served as reference measurements. The athlete wore reflective markers on eight landmarks to track her motions. Markers were applied on joints of the wrists, the elbows, the shoulders, the hip center, and down the neck with the least possible number of occlusions, to analyze the length and angle of movement by the »x« axis, the height by the »y« axis. The distances of the analysis tests are shown in table 1 for the athlete of the Algerian Paralympic elite. We used dartfish 9 software 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. The films obtained for each try were phases of analysis for each new variable and try.

**Kinematic Variables:** Based on the similar studies (Abdelkader et al., 2020; Banja, 2007; Banja, T & Tashiro T., 2004; R. M. Bartlett, 1992; Frossard et al., 2013a; Yu et al., 2002), several variables of the discus throw activity class F57 at start and finish were analyzed and calculated: 1/ The first phase (start throwing), we have the variables: the number of swings (number), standby time (second), the wrist angle of the throwing hand (degree°), cubitus angle of the throwing hand (degree°), cubitus angle of the freehand (degree°), trunk angle (degree°), shoulder angle of the freehand (degree°). 2/ The second phase (finish throwing), we have the variables: digital level (meter), cubitus angle of the throwing hand (degree°), cubitus angle of the freehand (degree°), trunk angle (degree°), shoulder angle of the throwing hand (degree°), head tilt angle (degree°), throwing angle (degree°), time of throwing (second), disk flight time (second), shot height (centimeter), total performance time (second).

**Figure 1.** The method chosen to capture video of the variables in discus throw performance.

**Statistical Analysis:** The data analysis procedures used in this study consists of the computation of the means, standard deviations (SD), standard deviation error (Std.E), minimum and maximum value as descriptive statistics, and the Pearson test for the correlations between all variables identified in similar studies (Abdelkader, Madani, and Bouabdellah, 2018; Benelguemar et al., 2020; Guebli, Bessenouci, et al., 2018; Henn et al., 2020; Zerf Mohammed et al., 2015). We used SPSS (SPSS for Windows, version 22.0, SPSS Inc. Chicago, Illinois, USA) statistical program for that statistical analysis of the data obtained.

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RESULTS

Table 1. Description Results of the Algerian World Champion of Discus Throw Class F57 “Saifi Nassima” in the kinematic analysis of his Performance

| Variables                                | Stage I  | Stage II |
|------------------------------------------|----------|----------|
| Digital level                            | -        | 33.25± 1.235 |
| The number of swings                     | 5.33± 0.516 | 5.000/6.000 |
| Standby time (s)                         | 6.38± 0.273 | 6.200/6.810 |
| The wrist angle of the throwing hand (°) | 136.50± 5.205 | 126.000/139.000 |
| Cubitus angle of the throwing hand (°)   | 161.00± 3.687 | 154.000/164.000 |
| Cubitus angle of the free hand (°)       | 164.00± 2.190 | 160.000/166.000 |
| Trunk angle (°)                          | 22.00± 1.095 | 20.000/23.000 |
| Shoulder angle of the free hand (°)      | 60.50± 0.836 | 59.000/61.000 |
| Head tilt angle (°)                      | -        | -        |
| Throwing angle (°)                       | -        | -        |
| Time of throwing (s)                     | -        | -        |
| Disk flight time (s)                     | -        | -        |
| Total performance time (s)               | -        | -        |

Table 1; shows the description results of performance kinematic analysis for our sample “Saifi Nassima” (the Algerian World Paralympic Champion, Class F57) in discus throw activity during the first and second stage of performance (start & finish throwing), the results explain 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 (І and ІІ).

| Stage І                          | Stage ІІ                          |
|---------------------------------|-----------------------------------|
| Digital level                   | Digital level                     | Cubitus angle of the throwing hand (°) |
| Standby time (s)                | - .895*.016                       | .864*.027 |
| Cubitus angle of the throwing hand (°) | .993**.000                       | -.872*.023 |
| Trunk angle (°)                 | .940**.005                        | .939**.005 |
| Cubitus angle of the free hand (°) | .825*.043                        | .995**.000 |
| Number of swings                | Cubitus angle of the free hand (°) | -.884*.019 |
| Standby time (s)                | Cubitus angle of the free hand (°) | -.916*.010 |
| Cubitus angle of the throwing hand (°) | - .916*.010                      | - .911*.011 |
| Trunk angle (°)                 | Cubitus angle of the free hand (°) | .833*.039 |
| Shoulder angle of the free hand (°) | .873*.023                        | -.882*.020 |
| Disk flight time (s)            | Disk flight time (s)              | .870*.024 |
| Total performance time (s)      | Total performance time (s)        | .934**.006 |

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

| The variables correlated between stage i & stage n | Cubitus angle of the throwing hand n (°) & .880* & Cubitus angle of the throwing hand i (°) & Displacement (s) & .824* |
|---------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| The number of swings | Cubitus angle of the throwing hand n (°) | .021 | Cubitus angle of the throwing hand i (°) | Disk flight time (s) | .044 |
| Trunk angle n (°) | .980** | .001 | Cubitus angle of the throwing hand n (°) | Total performance time (s) | -.824* |
| Cubitus angle of the throwing hand n (°) | -.880* | .021 | Cubitus angle of the throwing hand i (°) | Disk flight time (s) | -.939** |
| Time of throwing (s) | -.813* | .049 | Trunk angle i (°) | .820* | .046 |
| Total performance time (s) | .985** | .000 | | | |
| Standby time (s) | Cubitus angle of the throwing hand n (°) | .050 | Shoulder angle of the throwing hand n (°) | .907* | .013 |
| Shoulder angle of the throwing hand i (°) | .907* | .013 | Standby time (s) | -.907* | .013 |
| Trunk angle n (°) | -.898* | .015 | Cubitus angle of the freehand i (°) | | |

*(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 i of discus throw (start throwing), and in the second stage n (finish throwing), also between kinematic variables of first and second stage in discus throw.

The significant correlation was observed at p level (1-tailed) and degrees of freedom (n-1) between the values of kinetic performance in the first stage i (start throwing), the correlations are positive significant in; the digital level with cubitus angle of the throwing hand at (p< .001), trunk angle at (p< .005), and with cubitus angle of the freehand at (p< .05). The cubitus angle of the throwing hand with trunk angle, and trunk angle with cubitus angle of the freehand, and shoulder angle of the freehand at (p< .05). The correlations are negative significant in; the number of swings with cubitus angle of the freehand, standby time with cubitus angle of the throwing hand, and digital level with standby time at (p< .05).

The significant correlation was observed at p level (1-tailed) and degrees of freedom (n-1) between the values of kinetic performance in the second stage n (finish throwing), the correlations are positive significant in; the digital level with cubitus angle of the throwing hand at (p< .05), with disk flight time at (p< .005), and with throwing angle at (p< .01). The shoulder angle of the throwing hand with cubitus angle of the freehand at (p< .005). The disk flight time with total performance time at (p< .01). The cubitus angle of the throwing hand with disk flight time at (p< .05). The correlations are negative significant in; the trunk angle with cubitus angle of the freehand and the digital level with total performance time, and with trunk angle at (p< .05). The cubitus angle of the throwing hand with trunk angle at (p< .05).

The significant correlation was observed at p level (1-tailed) and degrees of freedom (n-1) between the values of kinetic performance in the first i and second n stage (start and finish throwing), the correlations are positive significant in; the number of swings with trunk angle n at (p< .005). The standby time with total performance time at (p< .001). Cubitus angle of the freehand i with shoulder angle of the throwing hand n at (p< .05). The cubitus angle of the throwing hand n with cubitus angle of the throwing hand n, and with disk flight time at (p< .05). The trunk angle i with cubitus angle of the throwing hand n at (p< .05), and with disk flight time at (p< .05). The correlations are negative significant in; the number of swings with cubitus angle of the shooting hand n, and with cubitus angle of the throwing hand n at (p< .05). The standby time with time of throwing, the cubitus angle of the freehand i with trunk angle n, the
The cubitus angle of the throwing hand i with total performance time, and the trunk angle i with throwing angle at (p< .0.05).

**DISCUSSION**

The goal of this study is to analyze the kinematical variables of discus throw activity in Para-Athletics (class F57) and their relationships with digital level achievement. The cubitus angle of the shooting hand, throwing angle, and trunk angle values presented a good correlation with digital level achievement (r=.000, r=.000, r=.005) in the phases of throwing. The most significant correlation value was between the standby time and total performance time (r=.000). It was probably due to the fact that the standby time was not more than 65% from total performance time of throwing during trials in this study, but the best throw happened with a short time in total performance time. Therefore, the increase of angular velocity performance probably affects positively the discus flight time and increases the range (Abdelkader, Madani, Adel, et al., 2018). There is a linear correlation between disk flight time total performance time (r=.006), and this is an important factor (Frohlich, 1981). These correlations with digital level show that initial discus speed correlates strongly to flight distance by able-body (Leigh & YU, 2007). The angular velocity determines the flight distance when there are few changes from angle and height (Banja, T. and Tashiro T., 2004). This study has found a small variation in time phases of discus throw where the release angle of discus (41.480±1.503) presented does not differ much from the values of old able-body throwers papers (Altmeyer et al., 1994; Burke, 1988; Ganslen, 1964; Gregor et al., 1985; Seo et al., 2012), which was probably caused by methodological data treatment problems at that time. It also agrees with evaluation on disabled thrower for the same functional class (Chow and Mindock, 1999). The values are between 35° - 45°. This is a clear indication that the achievement of the ideal angle at the start was good for the athlete. However, this was at the expense of reducing the starting speed. This is not compatible with the integration of all factors of discus throw; which is supposed to launch the disk at the ideal angle and with a very high starting speed, as achieving this good angle with the required speed means that the athlete has made proportional values for each of the horizontal and vertical forces variables. Thus, that will achieve an ideal angle and good starting velocity to achieve the excellent mechanical performance of the throw. On the one hand, it agrees with other recent papers (Abdelkader, Madani, Adel, et al., 2018; R. M. Bartlett, 1992; Frossard et al., 2013b; Leigh et al., 2010) and computational simulations for the kinematic angle values close to this study (Sueyoshi and Maruyama, 1992). On the other hand, these differences in the timing of movement for each athlete indicates the specific characteristics of kinetic performance according to his medical classification and degree, and this causes a discrepancy in the distribution of time along the technical stages of discus throwing.

Figure 2. Describe the performance system in discus throw, forces, horizontal and vertical variables.

Finally, according to our kinematical analysis in discus throw, most basic kinematic variables effective in discus throw techniques of disabled female athletes, are the cubitus angle of the shooting hand, trunk angle, and with cubitus angle of the free hand in the first phase (start throwing), and with cubitus angle of the shooting hand, disk flight time, total performance time,
and with throwing angle in the second phase (finish throwing) were significant with the digital level achievement. In addition, the kinematic variables in the performance of our sample like cubitus angle of the freehand, shoulder angle of the freehand, disk flight time, were important for effective and supportive for basic variables correlated to digital level achievement. Thus, combining angular motion and arm length to allow for the release speed to be as large as possible. With increase angular motion and the longest possible arm length, the release speed will be at its greatest, allowing for peak performance to occur. As the optimum height, release is seen to be at shoulder height at the point where the discus is leaving the hand, to allow for the discus to reach the highest release speed and the optimum angle of release to be created. The optimum angle of release is individual but is aimed to be between 35 and 45 degrees (Delgado, 2012).

The kinematical analysis of performance is very important for achieving the digital level (Arguz et al., 2021), for that, we need to focus on applying biomechanical principles during kinetic performance (Abdelkader et al., 2021). It also ensures 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. Thus, the athletes must limit the values of kinetic performance variables that contribute to achieving the ideal flight path for the disc, by controlling the basic variables in performance, beginning with the extension of the freehand (cubitus angle of the freehand) and the curvature of the trunk (trunk angle), which will directly affect the throwing hand (cubitus angle of the throwing hand), and the angle of throwing. This is a key factor in increasing the timing of flight the disk and the total performance time, bearing in mind that the faster the performance in the throwing stage (time of throwing), the higher, faster the disk will gain (disk flight time).

CONCLUSIONS

This study aims to analyze the kinematical variables of discus throw activity in Para-Athletics (Class F57) and their relationships with digital level achievement. The interpretation of kinetic performance variables is significant to achieve the best digital level of athletes in this class (F57). As a result, we confirm that: 1) The decrease in the variables value of time in throwing phases affects the digital level achievement; in addition, the degree of trunk angle variable. 2) The decrease in the value of throwing angle variable (between 38° - 43°) in second phase of throwing (finish) affects the digital level achievement. 3) The importance of the cubitus angle of the shooting hand appears significantly during the kinetic performance. Thus, we proved, that there are kinematical variables in the kinetic performance that are influenced by the level of digital achievement due to the indications of statistical relationships with the digital level achievement in the stages of throwing discus (cubitus angle of the throwing hand, trunk angle in the first and second stage, standby time, cubitus angle of the freehand in first stage, and disk flight time, throwing angle, total performance time in second stage).

REFERENCES

Abdelkader, G., Madani, R., Adel, B., Bouabdellah, S. (2018). Sporting events among the disabled between excellence and ideal in motor performance. International Journal of Physical Education, Fitness and Sports, 7(3), 66–71. https://doi.org/10.26524/ijpefs1837

Abdelkader, G., Madani, R., Bouabdellah, S. (2018). Impact of the collision and push angles on the phases hop, step and jump in the triple jump and their relationship to the stage of take-off. European Journal of Physical Education and Sport Science, 4(3), Article 0. https://oapub.org/edu/index.php/ejeps/article/view/1573

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Abdelkader, G., Madani, R., Bouabdellah, S. (2020). Kinematical variables analysis of shot-put activity in para athletics (class F32/33) and their relationships with digital level achievement. *International Journal of Sport Exercise and Training Sciences, 6*(2), 65–72. https://doi.org/10.18826/useeabd.709944

Abdelkader, G., Madani, R., Bouabdellah, S., Erkmen, N., Mohammed, Z., Boyalı, E. (2021). The contribution of biomechanical analysis technology to improve the assessment of students during certain school sports activities (long jump). *Kinestetik: Jurnal Ilmiah Pendidikan Jasmani, 5*(2).

Altmeier, L., Bartonietz, K., Krieger, D. (1994). Technique and training: The discus throw. *Track & Field Quarterly Review, 94*(3), 33–34.

Arguz, A., Guebli, A., Erkmen, N., Aktas, S., Regueig, M., Er, Y. (2021). *Biomechanical analysis of accuracy penalties-kicking performance for Turkish Soccer players: Group-based analysis without goalkeeper.*

Auriemma, M., De Luigi, A. J. (2018). Adaptive Throwing Sports: Discus, Javelin, Shot Put, and Boccia. In *Adaptive Sports Medicine* (pp. 301–312). Springer.

Banja, T. (2007). Kinematics and aerodynamics parameters on paralympic discus throw. *ISBS-Conference Proceedings Archive.*

Banja, T, Tashiro T. (2004). Three Dimensional Kinematic Analysis Of Disabled Discus Throwing. *Centro Esportivo Virtual, 2, 300–303. http://cev.org.br/biblioteca/three-dimensional-kinematic-analysis-of-disabled-discus-throwing/

Bartlett, R. (2000). Principles of throwing. *IOC Encyclopedia of Sports Medicine: Biomechanics in Sport, 6*, 365–380.

Bartlett, R. M. (1992). The biomechanics of the discus throw: A review. *Journal of Sports Sciences, 10*(5), 467–510. https://doi.org/10.1080/02640419208729944

Benelguemar, H., Bouabdellah, S., Mouissi, F. (2020). The kinematical analysis of blocking skill in volleyball and their relationships with the explosive force of lower limbs. *International Journal of Sport Exercise and Training Sciences - IJSETS, 6*(2), 73–79. https://doi.org/10.18826/useeabd.731462

Brittain, I. (2016). *The Paralympic Games explained* (Second Edition). Routledge.

Burke, S. (1988). Shot put and discus throw. *Track and Field Quarterly Review, 88*, 25–29.

Chow, J. W., Mindock, L. A. (1999). Discus throwing performances and medical classification of wheelchair athletes. *Medicine and Science in Sports and Exercise, 31*(9), 1272–1279. https://doi.org/10.1097/00005768-199909000-00007

Dai, B., Leigh, S., Li, H., Mercer, V. S., Yu, B. (2013). The relationships between technique variability and performance in discus throwing. *Journal of Sports Sciences, 31*(2), 219–228. https://doi.org/10.1080/02640414.2012.729078

Dapena, J. (1994). An analysis of angular momentum in the discus throw. *Journal of Biomechanics, 27*(6), 660.

Delgado, C. (2012). The Biomechanical Analysis of the Discus Throw: Stages and Suggested Training Techniques. *The International Journal of Sport and Society, 2*(4), 1–10. https://doi.org/10.18848/2152-7857/CGP/v02i04/53881

Frohlich, C. (1981). Aerodynamic effects on discus flight. *American Journal of Physics, 49*(12), 1125–1132. https://doi.org/10.1119/1.12560

Frossard, L. A., O’Riordan, A., Goodman, S. (2005). Applied biomechanics for evidence-based training of Australian elite seated throwers. *International Council of Sport Science and Physical Education Perspectives Series. https://eprints.qut.edu.au/2713/

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Frossard, L. A., O’Riordan, A., Smeathers, J. (2013a). Performance of elite seated discus throwers in F30s classes: Part I: does whole body positioning matter? Prosthetics and Orthotics International, 37(3), 183–191. https://doi.org/10.1177/0309364612458685

Frossard, L. A., O’Riordan, A., Smeathers, J. (2013b). Performance of elite seated discus throwers in F30s classes: Part II: does feet positioning matter? Prosthetics and Orthotics International, 37(3), 192–202. https://doi.org/10.1177/0309364612458686

Ganslen, R. V. (1964). Aerodynamic and mechanical forces in discus flight. Athletic Journal, 44, 50–52.

Green, H. (2012). A kinematic analysis of adapted discus delivery. University of Wales Institute Cardiff.

Gregor, R. J., Whiting, W. C., McCoy, R. W. (1985). Kinematic analysis of Olympic discus throwers. Journal of Applied Biomechanics, 1(2), 131–138.

Guebli, A., Bessenouci, H. A. I., Regiueg, M. (2018). The compounds of some variables kinematics in the phases of triple jump and their relationships with the finale results-An analytical study of the elements of the Algerian elite team-. Journal of physical activity and sport, society, education and health, 1(1), 25–31. https://www.asjp.cerist.dz/en/article/67719

Guebli, A., Regiueg, M., Sbaa, B. (2018). The value of dynamic priorities in motor learning between some basic skills in beginner’s basketball, U14 Years. Sport Management and Sport Marketing, 12, 1. https://doi.org/doi.dai.waset.org/1307-6892/92495

Guebli, A., Regiueg, M., Sbaa, B., Erkmen, N., Holanda, F. J. de. (2020). The modern technology to stimulate and improve sports performance for the paralympic athletes. Journal of Physical Activity and Sport, Society, Education and Health, 3(2), 66–74. https://www.asjp.cerist.dz/en/article/128311

Abdelkader, G., Madani, R., Bouabdellah, S. (2018). Impact of the collision and push angles on the phases hop, step and jump in the triple jump and their relationship to the stage of take-off. European Journal of Physical Education and Sport Science, 4(3), 183–189. https://doi.org/10.5281/ZENODO.1221435

Hay, J. G., Yu, B. (1995). Critical characteristics of technique in throwing the discus. Journal of Sports Sciences, 13(2), 125–140. https://doi.org/10.1080/02640419508732220

Henni, A. B., Bouabdellah, S., Mouissi, F., Abdelkader, G. (2020). The kinematical analysis of static and dynamic balance variables and their relationships with the accuracy shooting in soccer players U16. International Journal of Sport Exercise and Training- IJSETS, 6(3), 97–104.

Hubbard, M., Cheng, K. B. (2007). Optimal discus trajectories. Journal of Biomechanics, 40(16), 3650–3659.

Leigh, S., Liu, H., Hubbard, M., Yu, B. (2010). Individualized optimal release angles in discus throwing. Journal of Biomechanics, 43(3), 540–545. https://doi.org/10.1016/j.jbiomech.2009.09.037

Leigh, S., Yu, B. (2007). The associations of selected technical parameters with discus throwing performance: A cross-sectional study. Sports Biomechanics, 6(3), 269–284. https://doi.org/10.1080/14763140701489744

Martins Freire, G., Pedro Moraes, M., Sales Bocalini, D., Massoli Rodrigues, G. (2017). Changes in throwing sports rules: Implications about the performance of Paralympic athletes.

Morriën, F., Taylor, M. J. D., Hettinga, F. J. (2017). Biomechanics in paralympics: Implications for performance. International Journal of Sports Physiology and Performance, 12(5), 578–589. https://doi.org/10.1123/ijspp.2016-0199

Nassima Saifi—Athletics | Paralympic Athlete Profile. (2019). International Paralympic Committee. https://www.paralympic.org/nassima-saifi

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O’Riordan, A., Frossard, L. A. (2006). Seated Shot Put – What’s it all about? Modern Athlete and Coach, 44(2), 2–8.

Seo, K., Shimoyama, K., Ohta, K., Ohgi, Y., Kimura, Y. (2012). Aerodynamic behavior of a discus. Procedia Engineering, 34, 92–97. https://doi.org/10.1016/j.proeng.2012.04.017

Sueyoshi, Y., Maruyama, A. (1992). Optimal release angle on discus throw through computer simulation. Journal of Biomechanics, 25(7), 717.

Yu, B., Broker, J., Silvester, L. J. (2002). Athletics: A kinetic analysis of discus-throwing techniques. Sports Biomechanics, 1(1), 25–45.

Mohammed, Z., Idriss, M. M., Ali, B., Nasreddin, B. M., Abd-el-Kader, G. (2015). The impact of the techniques and tactics appropriate by the athletes in phase triple jump and their relationships with the finale results. Journal of Sports Science, 3(4).

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