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SHOT PUT KINEMATICS OF WORLD CLASS ATHLETES WITH AN INTELLECTUAL DISABILITY

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The purpose of this study was to identify basic kinematics differences in shot put kinematics between athletes with an intellectual disability (ID athletes) and able minded athletes. Data collection took place at the 2010 INAS athletics world indoor championships for athletes with an intellectual disability. Four high speed (100Hz) video cameras were utilized to observe 3D kinematics of the shot using the DLT method. The performance of ID athletes observed in this study was much lower compared to the performance of world class able minded athletes described in the literature. An analysis of basic kinematic characteristics of the gliding technique of the ID athletes revealed that they use a reduced acceleration path to release the shot, leading to a reduced speed of release.

KEY WORDS: biomechanics, athletics, Paralympic sport.

INTRODUCTION: Athletes with an intellectual disability are to be re included to the 2012 London Paralympic Games. A prerequisite of the International Paralympic Committee for the inclusion to the Games is that the disability represents a constraint to performance in the individual sport. In London's track and field events, ID athletes will be able to compete in the long jump, shot put and the 1500m run. Therefore it must be proven that intellectual disability is a performance limiting factor in these events.
The purpose of this study was to make a comparison between the performances of the world's best ID shot putters and the performances of athletes without intellectual disability of different levels reported in the literature. Kinematic parameters describing the release of the shot as well as parameters describing the performance of prior phases were included in the comparison. This kinematic comparison is thought to be the starting point for further research aiming to clarify the dependency of shot put performance and intellectual ability.
Additionally to an intellectual disability other factors, like for example different levels of professionalism and restricted access to training facilities and training personal might result in a reduced performance of ID athletes. Therefore it was hypothesized that ID athletes would perform on a significant lower level than the world's best shot putters without intellectual disability.

METHODS: The performances of the six best male throwers of the 2010 INAS world indoor championships in athletics were analysed. No information concerning age, body mass, height et cetera were available from the athletes. Only the best throw of each athlete was included to this first analysis. Four high speed cameras (A602 fc, Basler AG, Ahrensburg, Germany) operating at 100Hz were used to capture the motion of the athletes. Two cameras were placed at a distance of approximately 12m on both sides of the throwing sector. One camera was filming from the back of the ring while the last camera was capturing images from the top of the athlete. All camera data was captured synchronously with a Vicon MX Control unit. The trajectory of the shot was digitized for each frame and camera perspective (Vicon Peak Motus 9.0). The three dimensional coordinates of the digitized points were calculated using the DLT method (direct linear transformation; Abdel-Aziz and Karara, 1971). Data was scaled using a 1x1x2 iron calibration frame visible to all cameras placed in the middle of the shot put ring. A fourth order zero lag Butterworth low pass filter with a cut off frequency of 4Hz was applied to smooth the scaled coordinates of the shot. Since all athletes

were using the gliding technique, the analysis of the entire throw was subdivided into the following functional phases (based on Marhold 1964, definitions are given for a right handed athlete):

1. Glide: from last contact of the right foot until first contact of the same foot.
2. Transition: from first contact of the right foot until first contact of the left foot.
3. Release: from end of transition phase until the last picture the hand is in contact with the shot.

Parameters included into the analysis were: Release speed, angle and position (vertical and horizontal), as well as horizontal shot position at the limits of each functional phase and distance travelled and time spent in each phase.
Results were compared to published literature of world class and lower level able bodied athletes. Since only mean values and standard deviations could be obtained from the published literature no further statistical testing could be performed.

RESULTS: The average distance reached by the athletes of this study was 11.93±1.2m, indicating a very poor level of performance compared to the distances of elite able minded athletes (for example Bartonietz and Borgström 1995, Tsirakos et al. 1995 group B). The best result of 14.07m represented a new world record for ID athletes. Table 1 gives an overview of the release parameters of the shot in this study compared to selected values from the literature.

Table 1
Release parameters of the shot

	n	Release angle [°]	Release velocity[m/s]	Release height[m]	Release distance[m]	Official distance[m]
ID athletes	6	36.6 ± 2.1	9.7 ± 0.6	2.23 ± 0.1	0.06 ± 0.09	11.93 ± 1.2
Bartonietz and Borgström (1995)	6	34.5 ± 2.7	-	-	-	19.39 ± 0.84
Dessureault (1978)	13	36.8 ± 4.8	11.4 ± 1.3	2.03 ± 0.09	-	14.82 ± 2.8
Tsirakos et al. (1995) group A	6	41.0 ± 1.4	11.6 ± 0.2	2.21 ± 0.09	-	15.66 ± 0.45
Tsirakos et al. (1995) group B	6	37.4 ± 2.9	13.0 ± 0.3	2.28 ± 0.05	-	19.29 ± 0.83

The studies of Bartonietz and Borgström (1995) and Tsirakos et al. (1995), group B give results of world class able minded shot putters while Dessureault (1978) and Tsirakos et al. (1995), group A present data of able minded athletes of an intermediate level (see mean distances in table 1). The horizontal position of the shot at release was not described in the selected literature sources, so a comparison cannot be conducted.
The release characteristics of the shot are the result of the performance in prior functional phases. To observe principal differences in the gliding technique between ID athletes and subject groups described in the literature, basic kinematic parameters of the shot are given in

the next section. Table 2 gives the results of the distances travelled by the shot during each functional phase and the duration of each of these phases.

Table 2
Functional phases parameters

	n	Distance glide [m]	Distance transition [m]	Distance release [m]	Duration glide [s]	Duration transition [s]	Duration release [s]
ID athletes	6	0.26 ± 0.03	0.18 ± 0.1	1.33 ± 0.06	0.14 ± 0.01	0.10 ± 0.05	0.32 ± 0.04
Dessureault (1978)	13	0.35 ± 0.05	0.18 ± 0.08	1.46 ± 0.17	0.16 ± 0.02	0.09 ± 0.05	0.29 ± 0.05
Tsirakos et al. (1995) group A	6	-	-	-	0.13 ± 0.01	0.09 ± 0.04	0.35 ± 0.03
Tsirakos et al. (1995) group B	6	-	-	-	0.14 ± 0.02	0.08 ± 0.03	0.34 ± 0.03

ID athletes cover on average a 9cm shorter distance during the glide phase and a 13cm shorter distance during the release phase compared to the results of Dessureault (1978). This reduced acceleration path is a clear restrictor of performance for ID athletes. No major differences were found for the functional phase durations.

DISCUSSION: The results found in this study clearly show that ID athletes perform on a level way below the level of world class able minded athletes and below the level of able minded athletes of intermediate levels described in the literature. Interpretations must be treated with some precaution, since no statistical testing could be performed due to a lack of single subject data described in the literature. Nonetheless, comparing means and standard deviations of the different data sets with partially large differences observed, confirm the interpretations given in this section. The clearest differences can be observed for the release speed of the shot. This is a result that could have been anticipated since release speed is the strongest predictor of the distance reached by the shot. Minor differences could be found for the release angle, with ID athletes releasing the shot at angles comparable to other studies, except Tsirakos et al. (1995), group A. Release height is strongly dependable upon body height, which might explain the small differences found between studies.
The main difference in the gliding technique was found to be a reduction of the acceleration path of the shot, which is indicated by a reduced horizontal distance travelled by the shot in the gliding and the release phase. No major differences were found for the durations of each functional phase. Therefore ID athletes conduct the gliding technique with a lower average speed, since they cover a shorter distance in the glide and release phase in approx. the same amount of time. It is a well-accepted theory, that a longer accelerative path of the

implement is a positive contributor to release velocity in all throwing events (see for example Zatsiorsky et al 1981).
As a result of the reduced length of the accelerative path, release speed of the shot is reduced for ID athletes, which explains most of the differences found for the official distance reached by the athletes. This could be a result of a poor execution of the gliding technique. Technique acquisition might be one major factor which is restricted by an intellectual disability. Nonetheless performing the gliding technique properly calls for a high potential force producing, especially for the muscle tendon units of the lower extremity. Without the using of further information concerning for example force producing capacities or training history of the athletes no conclusions concerning the exact reasons of the lower performance of the ID athletes can be drawn.

CONCLUSION: This study tried to identify the most basic kinematic differences in shot putting techniques of male athletes with a disability compared to athletes of different levels described in the literature. The most basic result was that the poorer performance of ID athletes was associated with a reduction of the acceleration path of the shot resulting in a lower speed of the shot at release. No conclusions can be drawn concerning the roots of this poor execution of the gliding technique unless further individual information of the athletes is included into the biomechanical analysis. This should be one goal of future analysis as well as a more detailed description of kinematic differences between ID and able minded athletes.

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