

## BIOMECHANICAL AND KINEMATIC ANALYSIS OF SPIRE THROWING PERFORMED BY THE MACEDONIAN RECORD HOLDER DEJAN ANGELOVSKI

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### Abstract

Certain kinematical and biomechanical parameters are used by the coaches in athletics with the purpose of bettering the results of the top athletes. The coaches and other athletics experts use certain video methodologies analyze their athletes through certain kinematical and biochemical parameters. These analysis are performed with the purpose of bettering or correcting the technique used by the athletes. The research is conducted on the Macedonian record holder in javelin throws Dejan Angelovski in order to determine the kinematic and biomechanical parameters in javelin throws in six series as permitted by the rules in athletic competitions. Based on the gathered data it has been concluded that D.A. possesses good techniques for javelin throws. He possesses high quality motor performances, able to achieve even greater distances compared to the current best in Macedonia, 76.40 m. Furthermore, the establishing of a system for training in micro-cycles and macro-cycles, should be envisioned in such way so it includes motor exercises of force, speed, speed durability and flexibility, which should enable him the establishing of a basis for their perfection and upgrade and accumulation of skill for successful competition.

**Key words:** kinematic, biomechanical, parameters, analysis, javelin throw

### Introduction

The research presents an experimental procedure conducted in a competitive period, in which the seven-day Applied Micro cycle training, and motor variables are applied to test the motor skills of the analyzed launcher, a qualitative analysis of biomechanical and muscular analysis. Throwing a spear from a cinematic perspective present a mono structurally irregular movement by reciprocating linear trajectory, from the physiological aspect of throwing a spear some characteristic are short linear movements from the start to maintain the equilibrium position after ejection lance the whole act takes 7 seconds with maximum intensity where are dominating the explosive movements of the legs through the impulse to the action phase of maximum exertion.

As a dynamic system of movement from of neurophysiologic aspect they represent motor habits formed in the central nervous system and are outlined as kinetic program. Throwing a spear present a dynamic stereotype or launcher system – equipment with certain special structure, where the system of motor units acts for processing information.

Biomechanical structure of the technique Javelin consists of four interconnected phases:

#### Phase momentum

- \* Phase overtaking the spare
- \* Phase of maximum exertion
- \* Maintenance phase of equilibrium position

Subject of research is micro seven-day cycle of training which is used in competitive period, motor tests with specific elements for testing the ability of thrower, biomechanical - kinematic variables, qualitative biomechanical analysis of dumping and muscle analysis. Aim of the study is:

- To determine the values of the applied micro seven-day cycle of training;
- To determine the values of motor tests to check the capabilities of the thrower;
- To determine the values of biomechanical - kinematical variables in the act of throwing;
- The qualitative biomechanical analysis will determine the structure and biomechanical optimality of spear throwing and
- Muscle analysis that determines how and which muscles participate in the act of throwing a spear.

### Methods

#### The sample of subjects

The sample of respondents is represented by thrower, a Macedonia record holder Dejan Angelovski, a member of AK "Rabotnicki" - Skopje, with a record of 76.46 meters. Born on 03. 1. 1976 in Skopje, started with athletics since 1991. Significant results started to achieve in 1995 with the result of 63.22 m. Took part in competitions of Balkanijads where he took from first to third place. The European and world championships, failed to enter the finals.

Its development is fast, made results of 67.26, 69.48, in 2001 throws over seventy meters - 71.80 meters. With these results he is between three throwers in the Balkan (those who competed at Balkanijads). As great quality he performed with dual registration AK "Class" of the Faculty of Sport and Physical Education "VasilLevski" in Sofia. Last participated in the World Championships in Helsinki 2005 but failed to enter the finals, bad weather affected much of his performance. He competes and is an absolute champion of Macedonia, the results are somewhat weaker due to injuries that follow.

#### *Research methods*

In the research process we used video Count method to record the thrower from the beginning of throwing the spear and maintaining a balanced position. This method holds a program which can record throwers movements which can be extracted in number of parameters, in our case 19 variables that we consider in monitoring the technical characteristics of the pitcher are sufficient, or other parameters that we will extract in the following researches by our record.

#### *Conditions of measurement*

Measurement of the respondent was conducted on athletic stadium which usually take place in training. Time measurement is determined by the time the scheduled competition (17 pm). During the competition 8 spear throwers entered the finals. Our respondent threw the last, because the weaker throwers according to the results achieved throw before our analyzed thrower. Dejan Angelovski in all six series made a result and he didn't make any error of line while throwing and the spear had sting peak.

### **Results and discussion**

#### *Micro seven-day cycle training*

##### *First training*

- \* Warming Time 10 min.
- \* Exercises for shaping - stretching 15 min.
- \* Progressive acceleration of high start 3 x 80 cm (1.5 min breaks.)
- \* Weights: from below to build a 3 x 8 x 130 kg.
- \* For legs 3 x 3200 kg.
- \* Dealers press - 3 x 2 x 130 kg.
- \* Progressive accelerations 3 x 60 m. (pause 2 min.)
- \* Shot put 4 kg. from a place like mast by 30 times
- \* Running loos 5 minutes.

##### *Second Training*

- \* Warm-up 12 min.
- \* Stretching exercises 20 min.
- \* Progressive 12 running spear 30m.
- \* 30 javelin throws with three steps with 60% strength
- \* 15 javelin throws with a short run-up and flying steps with 70% strength
- \* 8 shots with full momentum with 70% strength
- \* In the area of 30 m. 6 series jumps

- \* In the area of 30 m. triple jumps as one of the other foot alternately three series
- \* Running 8 min.

##### *Third training*

- \* Warm up for 10 minutes.
- \* Stretching exercises 15 min.
- \* Progressive acceleration of high start 4 x 60 m.
- \* Weight: Disposal of building built before 3 sets 95 kg.
- \* For feet position 3 x 6 x 200 kg.
- \* Raising the arms of a seated position behind the head to overhead lifts 3 x 50 8 kg.
- \* One and the other side plates 3 x 15 kg x 20th
- \* Progressive running 5 x 50 m with 50% speed
- \* Running 8 min.

##### *Fourth training*

- \* Warm-up 13 min.
- \* Stretching exercises 20 min.
- \* Progressive accelerations 3 x 100 m. 80% speed (breaks 2 min.)
- \* Sprint high lane 5 x 20 cm (1.5 min breaks)
- \* Sprint high start 5 x 30th (pauses 1.5 min)
- \* Sprint high start 3 x 60 m (2 min breaks)
- \* Running 6 min.

##### *Fifth training*

- \* Warm-up 10 min,
- \* Stretching exercises 15 min.
- \* Weight:
- \* From the bottom raising to build a 3 x 8 x 90 kg.
- \* Disposal of building built before 3 x 10 x 50 kg
- \* For ups and downs 3 feet x 15 x 150 kg.
- \* For legs with a weight on your back climbing the bench 30 cm high x 10 x 3 150 kg.
- \* Progressive running 3 x 60m. 50% speed (relaxation)
- \* Running 5 min.

##### *Sixth training*

- \* Warm-up 12 min.
- \* Stretching exercises 20 min.
- \* Stretching exercises spear 10 min.
- \* Running a spear like a run of 30 m. 8 x 30 m. (pauses 1.5 min.)
- \* In the space of 13 m. entry into throwing steps with particular emphasis on cross step 12 throws with 80% strength (3 min breaks).
- \* Throwing steps 6 series with 80% strength (breaks 3 min.)
- \* Jump from place 8 times
- \* Triple jump from place 8 times
- \* Fifth jump 4 times
- \* Tenth jump 4 times (rest between sets 3 min.)
- \* Running 5 min.

##### *Seventh training*

- \* Warm-up 12 min.
- \* Stretching exercises 20 min.
- \* A progressive accelerations 6 x 80 m with 80% speed (breaks 1.5min.)
- \* Put 7,257 kg. throws down the front with two hands 20 times
- \* Put 7,257 kg. shots behind 20 times

- \* 3kg shot put. Throwing from a place like mast 2 x 25 shots with 100% strength
- \* 4 kg shot put throwing out overhead throws 20
- \* Spear of 900 grams. the place in three steps with 80% strength 12 throws
- \* Spear of 900 grams. short momentum with three steps throwing 100% strength 6 times
- \* Running 5 min

After completion of the micro cycle of seven-day training, the respondent was tested for 16 motor variables commonly used in the system of training to assess the abilities of javelin thrower D.A.

*Values of motor Tests:*

- Sprint 20m. - 2.8 sec.
- Sprint 30m. - 3.6 sec.
- Sprint 60 m. - 6.9 sec.
- Jump from place - 3.20m.
- Triple jump from place - 9.80 m
- Fifth jump place from - 14.80 m.
- Shot put 6 kg of -18.60 m.
- Shot put 6 kg. -the place back fed 20,50 m.
- Shot put of 7,257 kg. -place of 14.70 m.
- Shot put of 7,257 kg. -a rational technique 15,30 m.
- Throwing Disc 2 kg. -Technique 39,00 m.
- Weights - bench-press 190 pounds.
- With leg position- 300 kg.
- With leg position- 220 kg.
- Raising the chest down to -160 kg.
- Phasing out of the chest before the body -110 kg

*Biomechanical quality analysis*

In throwing spear biomechanical structure consists of 28 biomechanical variables:

- \* Throwing
- \* Home position start spear
- \* Closing the position Throws
- \* Concentric contraction of the plantar flexors in the upper ankle with central support, asymmetrical
- \* Eccentric contraction of the plantar flexors in the upper ankle, asymmetrical
- \* Concentric contraction of flexors in the knee joint with a central support, asymmetrical
- \* Concentric contraction of the extensors in the knee joint by a peripheral support, asymmetrical
- \* Eccentric contraction of the extensors in the knee joint, asymmetrical
- \* Concentric contraction of external rotators in the knee joint with a central support, asymmetrical
- \* Concentric contraction of the flexor in the hip joint with a central support, asymmetrical
- \* Concentric contraction of the extensors in the hip joint with peripheral support, asymmetrical
- \* Concentric contraction of internal rotators in the hip joint with peripheral support, asymmetrical
- \* Concentric contraction of external rotators in the hip joint with peripheral support, asymmetrical
- \* Concentric contraction of flexors in the wrist with a central support, asymmetrical
- \* Concentric contraction of the extensors in the elbow with a central support, asymmetrical
- \* Concentric contraction retro flexors of the joint of the shoulder with a central support, asymmetrical

- \* Abductors isometric contraction of the joint shoulder asymmetrically
- \* Concentric contraction retroabduktoranteflexion of the joint of the shoulder with a central support, asymmetrical
- \* Concentric contraction of the flexors of the spinal column in the lumbar-thoracic part with peripheral leverage
- \* Concentric contraction rotation spinal column
- \* Maximum center of gravity of the body
- \* Rebound momentum with a smaller angle of eccentricity
- \* Swing with one hand in overcoming space
- \* Swing one leg of mastering space
- \* Movement of the center of gravity of the body in the sagittal plane
- \* Large supporting surface
- \* Open kinematic chain - with one foot support
- \* Closed kinematic chain - leg, pelvis, leg

*Muscle analysis for javelin*

Muscle analysis is very important for any coach working with spear throwers, because you know which muscles participate in the act of throwing, and will operate special exercises to develop the muscles of that group.

*Retro in wrist flexor shoulder*

*Agonists*

- m. Latisimusdorsi
- m. Deltoideus pars anterior

*Sinergist*

- m. Pectoralis major pars clavicularis
- m. Teres major
- m. Teres minor
- m. Triceps brachii

*Flexors of spine*

*Agonist*

- m. Rectus abdominis
- m. Oblicusexsternusabdominis
- m. Oblicusinternusabdominis

*Sinergist*

- m. Psoas major et psoas minor
- m. Extensorinazglobotnakolkot

*Agonist*

- m. Gluteus maximus
- m. Biceps femoris:
- m. caput longus
- m. caput brevis
- m. Semitendinosus
- m. Semimembranosus
- m. Aductormagnus

*Sinergist*

- m. Gluteus medius
- m. Piriformis
- m. Obturatoriusinternus
- m. Gemellus inferior
- m. Aductormagnus

Table 1. Biomechanical - kinematic variables

Series variables	1	2	3	4	5	6
A run length (m)	29.62	29.62	29.62	29.62	29.62	29.62
Length to throwing steps (m)	11.62	13.01	12.94	12.62	13.20	13.33
Length throwing steps (m)	18	16.61	16.68	17	16.42	16.29
Time to throwing steps (s)	3.00	3.00	2.86	2.28	3.08	2.95
Time throwing steps (s)	3.09	3.06	2.77	3.75	3.20	3.17
During the act of throwing (s)	6.09	6.06	5.63	6.03	6.28	6.12
Number of steps in the run-up	5	5	5	4	5	5
Number of steps in phase 2	5	5	5	6	5	5
Number of steps in the act of throwing	10	10	10	10	10	10
Cross step length (m)	1.30	1.27	1.56	1.64	1.69	1.56
Distance of 3 feet stage (cm)	0.98	1.10	1.04	1.08	1.11	1.13
Distance from the line of ejection (cm)	0.56	0.69	1.42	1.30	0.62	1.19
Throwing steps to speed (m / sec)	3.87	4.34	4.52	5.54	4.00	4.52
Speed in the second phase (m / sec)	5.83	5.43	6.02	4.53	4.11	5.14
Speed in the act of throwing (m / sec)	4.86	4.89	5.26	4.91	4.72	4.84
Length of the throw (m)	67.31	66.68	63.65	68.26	69.25	70.40
Difference of level (cm)	175.8	174.4	170.8	179.0	186.6	188.8
Offensive angle left leg	44	43	42	47	48	49
Initial angle of the spear in phase 3	46	47	47	48	49	50
Angle removing the spear	43	42	48	44	43	45
Speed emphasis on the right hand under the ejection	18.04	17.46	12.07	14.28	18.57	19.03
Initial velocity ejections spears	23.63	22.76	21.16	23.67	24.12	26.19

*Plantar flexor in the ankle and knee*

*Agonist*

- m. Biceps femoris:
- m. Caput longum
- m. Caput brevis
- m. Semitendinosus
- m. Semimembranosus
- m. Sartorius
- m. Triceps surae:
- m. Soleus
- m. Gastrocnemius
- m. Plantaris
- m. Peroneus longus

*Sinergist*

- m. Gracillis
- m. Popliteus
- m. Gastrocnemius
- m. Peroneus brevis
- m. Flexorhallucislongus
- m. Flexordigitorumlongus
- m. Plantaris

Biomechanical - kinematical variables are only part of the kinematic analysis that can explain throwing a spear during a match as in our case. The analysis covers spatial, time, speed and angle parameters of 19 variables, which does not mean that only these variables constitute the act of throwing on the contrary we singled out these parameters as one of the important parameters to throw the javelin further.

**Conclusion**

Micro cycle of seven-day training is designed on the way that the system psychomotor system elements have higher intensity, because training with loads of different types should be intense with oscillations with variable dynamics, and not to cause fatigue before the match. This micro cycle predicted the burdens of seven days since and our thrower will certainly enter in final no matter the strong competition. We wanted to see what effect it will have on the training subject, but we know that the application of factor and regression analysis will determine how it affects the training system, and especially the elements of the training, but this will be left for the following research. The system of training include strength, speed and explosive power, abilities that are important for success in throwing spear. The test values in the manifest space is done to assess how much the thrower has accumulated psychomotor skills in the preparation and competition period. The analysis of the results shows that the respondent possesses significant capabilities equal with those on top of the athletic sport. If the thrower possess high quality motor skills for throws over 80m, than the problem with low scores we should seek in analyzing the technique of throwing and biomechanical laws. Qualitative biomechanical analysis characterizes all the movements of the thrower of the preparatory phase to the ejection of the spear and maintaining balance. Muscle function analysis presents he muscular system that participates in the act of

throwing. Training with a predominance of power and explosive power you need to know the participation of muscles in throwing the spear that should be used in exercises with weights for the muscles that play a role in throwing spear. With the video method were extracted 19 biomechanical-kinematic variables that characterize spatial, time, speed and angle parameters that give the picture for all 6 shots and are responsible for the technical execution of the throw. A run which the respondent used is 30 m. The first part of a scramble, to entry in throwing steps the respondent passes 11.62 m. to 13.33 m. He passes the throwing steps with a length of 16.29 m. to 18m. The length of a scramble is enough to develop speed and harmonize the throwing steps, but in all 6 throws the length is different, though thrower has measured exactly. This means that steps vary in length which suggests the influence in taking the corners of the body and throwers hand, the movement of the arm at the time of disposal, provided that he throws the spear, as he steer the impact strength of the spear and will announce the explosive force of the machine to tip with larger initial speed. The time by which the moving subject in m/sec. during the throw is good, the difference of the movement in throwing steps in the first part is understandable, since passing greater length in that part make a gradual return to spear overcoming the body and characteristic of our launcher is that it makes twisted spear, which continues the way of swing before the ejection, which would strike action on the handle of a long journey in a short time. The distance after ejection of the spear from the line of phasing allows to

quench created inertia and no transgression. Angular parameters also vary in any turn, it is the hardest throwing spear to maintain adequate angle of movement of the throwing hand, to get to a position opposed to the level of that spear throwing and normal ejection angle - elevation, in which the respondent ranges from 47 ° to 49 ° condition that rolls up the trunk with the spear and the distance of the foot and block stepping leg is lowered center of gravity the body. Spear initial speed at the time of ejection is from 23.16 m/sec. to 28.11 m/sec. the final throw which achieved the greatest length and 70.49 m. It is noted in some throws great length and small value of the initial speed of the spear. We believe that this difference occurs because the positioning of the thrower then crossed up and rolls up his body and hand, and timely unable to direct the explosive force of the fingers of stepping leg through the knee, hip thrust, shoulder and arm. The long run-up and high speed that is thrown spear is the reason for the variation in any normal throwing larger or smaller oscillations in the length of throwing spear. The analysis of psychomotor tests concluded that Dejan Angelovski has quality motor skills equal with top spear throwers, but to reach their length will have to work a lot in technique and in all kinematic parameters and often in the pre competitive period in the second phase and during the competitive period should correct unfavourable movements. He should work in the training to take an advantageous angle and direction of the explosive force. Momentum will have to align with smaller fluctuations in order not to disrupt the cross-step setup then it depends on the efficient throwing.

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## BIOMEHANIČKA I KINEMATIČKA ANALIZA BACANJA KOPLJA IZVOĐENOG OD MAKEDONSKOG REKORDERA DEJANA ANGELOVSKOG

### Sažetak

*Određeni kinematički i biomehanički parametri su korišteni od trenera u atletici sa svrhom poboljšanja rezultata vrhunskih sportaša. Treneri i drugi atletski stručnjaci koriste određene video metodologije u svrhu analize svojih sportaša kroz određene kinematičke i biokemijske parametre. Ove analize su vršene sa svrhom poboljšanja ili korigiranja tehnike korištene od sportaša. Istraživanje je provedeno na makedonskom rekorderu u bacanju koplja u šest serija odobrenih pravilima u sportskim natjecanjima. Zasnovano na prikupljenim podacima zaključeno je da D.A. posjeduje dobre tehnike za bacanje koplja. On ima visokokvalitetne motoričke učinke, sposobne postići još veće udaljenosti u usporedbi sa trenutnom najboljom u Makedoniji, 76.40 m. Nadalje, uspostava sustava za treniranje u mikro-ciklusima i makro-ciklusima treba biti zamišljena na način da uključuje motoričke vježbe snage, brzine, brzinske izdržljivosti i fleksibilnosti brzine, što bi mu trebalo omogućiti uspostavu osnove za njihovo usavršavanje i nadogradnju te akumulaciju vještina za uspješno natjecanje.*

**Ključne riječi:** kinematika, biomehanički, parametri, analiza, bacanje koplja

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