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KINEMATIC ANALYSIS OF WRESTLER'S POSITION DURING THE PERFORMANCE OF TECHNIQUE OF SHOULDER THROW

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Abstract

Freestyle wrestling is one of the most used and highly efficient techniques during the race, which often ensures victory. This analysis included 10 high quality and experienced senior wrestlers of different categories. The technique of shoulder throw is accomplished with maximum engagement in both variants (high variant and low variant), without opponent resistance. The throw was recorded with three cameras (60Hz / s), while the processing of the material was done according to the process of APAS (Ariel Performance Analysis System) modules. At the end reads the data from the curves obtained for the displacements and the durations of the throwing techniques. The technique starts from the diagonal position of the thrower, and the throw is divided into three phases. For the first two phases the displacements of the main body parts of the wrestler in both variants were compared. During the second phase (opponent's grip) greater displacement of the right shoulder, left shoulder, right thigh, left thigh, right knee, left knee and center of gravity of the wrestler's body was observed in the anteroposterior direction (forward), compared to the other two directions. However, during the low throw variant performance the vertical direction displacement is greater than the high variant and this difference is highly significant ($p = 0.00$), for all analyzed body parts of wrestler and the center of gravity of his body.

Keywords: Shoulder throw, kinematic analysis, displacement, duration.

Introduction

The sport of wrestling involves a large number of techniques. As the opponents start the match from the stand, then the first actions of the wrestlers are attempts to throw the opponent. As a result of the great dynamics of the match and full contact with the opponent, every moving and technical element on the counter at any moment is opposed by him. If the opponent's reaction is timely and with maximum engagement, then attempting the attacker with the appropriate technique may be unsuccessful. Even in many cases the opponent with the realization of some (anti-technical) technique can suddenly bring him the match victory.

Throws are the most tempting techniques in wrestling and similar sports that have these techniques, such as in judo (Kano, 1994; Otaki and Draeger, 1996). Their successful performance enables the opponent to subdue him by knocking him down and gaining points depending on the position of the opponent's downfall. But, in many cases and situations of confrontation with the opponent the activity continues on the floor, so it is very important that the throw is frantic and with high amplitude. Successful selection of relevant techniques for each athlete must respond to them, and it depends on the trainers' sufficient knowledge of more

athletic characteristics. In this regard, the athlete's motor, technical, and morphological abilities must be taken into account in order to be able to master the techniques that respond to them.

The throws depend not only on the manner and style of their performance but also on the height of the opponent's body. Often the thrower may be of the same body mass category as the opponent, but with different body heights, which affects the efficiency of the technique (Melo, Santos, Teixeira, Piucco, 2012; Melo, Santos, Piucco, Teixeira, 2013). The development of biomechanical laboratory equipment has enabled the description of the movement of the body and its parts during the performance of most techniques. By defining the kinematic parameters in the three-dimensional system: displacement in all three directions, angles in the major parts of the body, velocities of the responsible parts of the body, acceleration in performing the appropriate techniques, etc., enables trainers to more easily distinguish the effects of different positions on the body, while performing throwing techniques. They are also able to more easily detect mistakes that occur during the performing of techniques and are then understood to be committed to correcting them.

The authors DeCastro N. and Wu T. (2015) in their study carried out the kinematic analysis of upper extremity movements and downward counter-pulling techniques. The study included a total of six male wrestlers, analyzed at 10 (key) points while performing several throws on either side. The results obtained were compared between the two sides of the technique, but no significant differences were found between the left and right sides of angular displacements, velocity and acceleration of the technique. Video analysis during the study showed that some of the wrestlers were more likely to use techniques where the upper limbs performed the main task, while others performed the techniques where the lower limbs and hips had the main engagement. Other studies have recently been conducted with the help of biomechanical analysis systems, especially with the aim of quantifying kinematic indicators (Yaremenko, 2014; Sinigovets, 2013).

Comparative analysis of the kinematic characteristics of the throwing technique in both variants (high variant and low variant) gives the opportunity to validate the specificity of the body position of the thrower. Whereas the analysed technique in the study is among the most applied in competitions, the description of the trajectory of movement of the main body parts and the center of gravity of the athlete's body during the performance of the technique is in the interest of accurate kinematic analysis. Another aim of the study is to compare the two most commonly used variants of the shoulder throwing technique.

Methods

In this study were included 10 high quality wrestlers, with over 6 years of senior experience, from different categories of the wrestling teams: 'Liria - Shkup' and 'Balkanec - Shtip'. The technique execution is done with maximum engagement in both variants, while the opponent (thrown) is of the same weight category (approximately the same body mass) and gives no resistance. The recorded material is processed according to the APAS (Ariel Performance Analysis System) module process. APAS integrates computer hardware and video processing with specialized software modules that perform data collection, analysis and presentation (Ariel Dynamics, 1994). The three Sanyo-type digital cameras (60Hz/s) were located at an angle of about 120 degrees from each other. The camera distance from the performance venue is 7-8 meters. Once the cameras have been fixed at the place where the technique is to be performed, the calibration frame (200x200x200) cm will be record. Then the calibration framework is

removed, and in that area (arena) the performance of techniques begins. For both variants of the technique in question after the film is cut, the wrestler's body leverage model is formed by 18 points of his body (Figure 1, Figure 2). After digitalization the image model is transformed from 2D to 3D. Then the signal is filtered (motion curve) for each point analyzed on all three axes of the system. At the end, can be read the data from the curves obtained for displacements, key angles, velocities and duration of throw. The technique starts from the diagonal position of the attacker, while the opponent's (thrown) feet are held parallel to each other. The throw is divided into three stages. The first phase begins with the right foot moving forward, continuing with the body turning so that both foots are positioned on the carpet (the imbalance of the opponent's body) (the imbalance of the opponent's body). The second phase (F2), the so-called grappling phase of the opponent's (packing), is to put the attacker in contact with the back on the opponent's body and loading him, so that his or her feet from the carpet begins to move (flight start). The third phase (F3), the so-called flight phase, begins by removing the opponent's soles from the carpet and continuing to lift, rotating and releasing the carpet until the first touch with any part of his body (photo 1, photo 2, photo 3, photo 4, photo 5, photo 6, photo 7, photo 8).

Figure 1. Phases (F1-photo 1, 2; F2-photo 3, 4, 5; F3-photo 6, 7, 8) of technique of shoulder throw – high variant

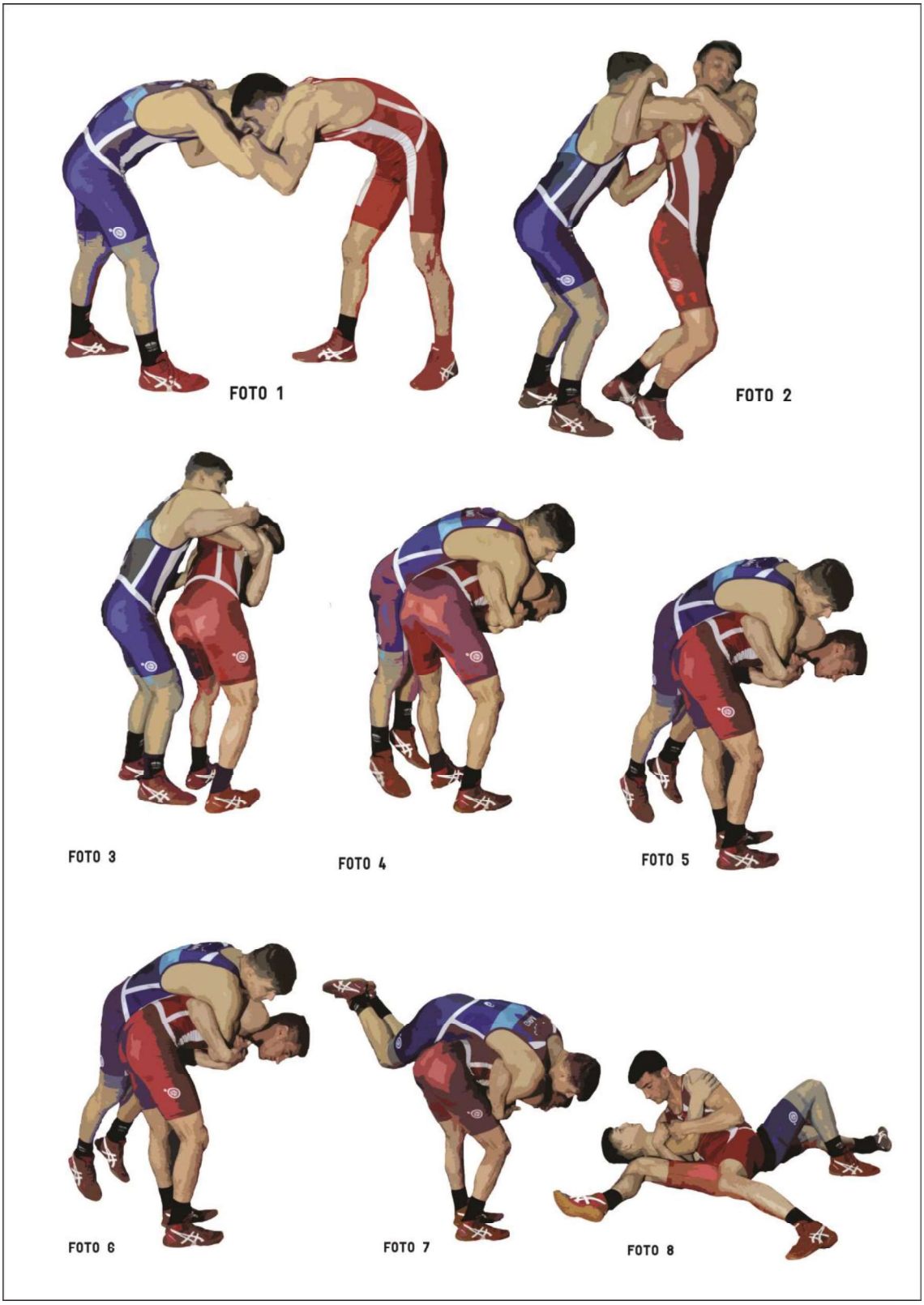
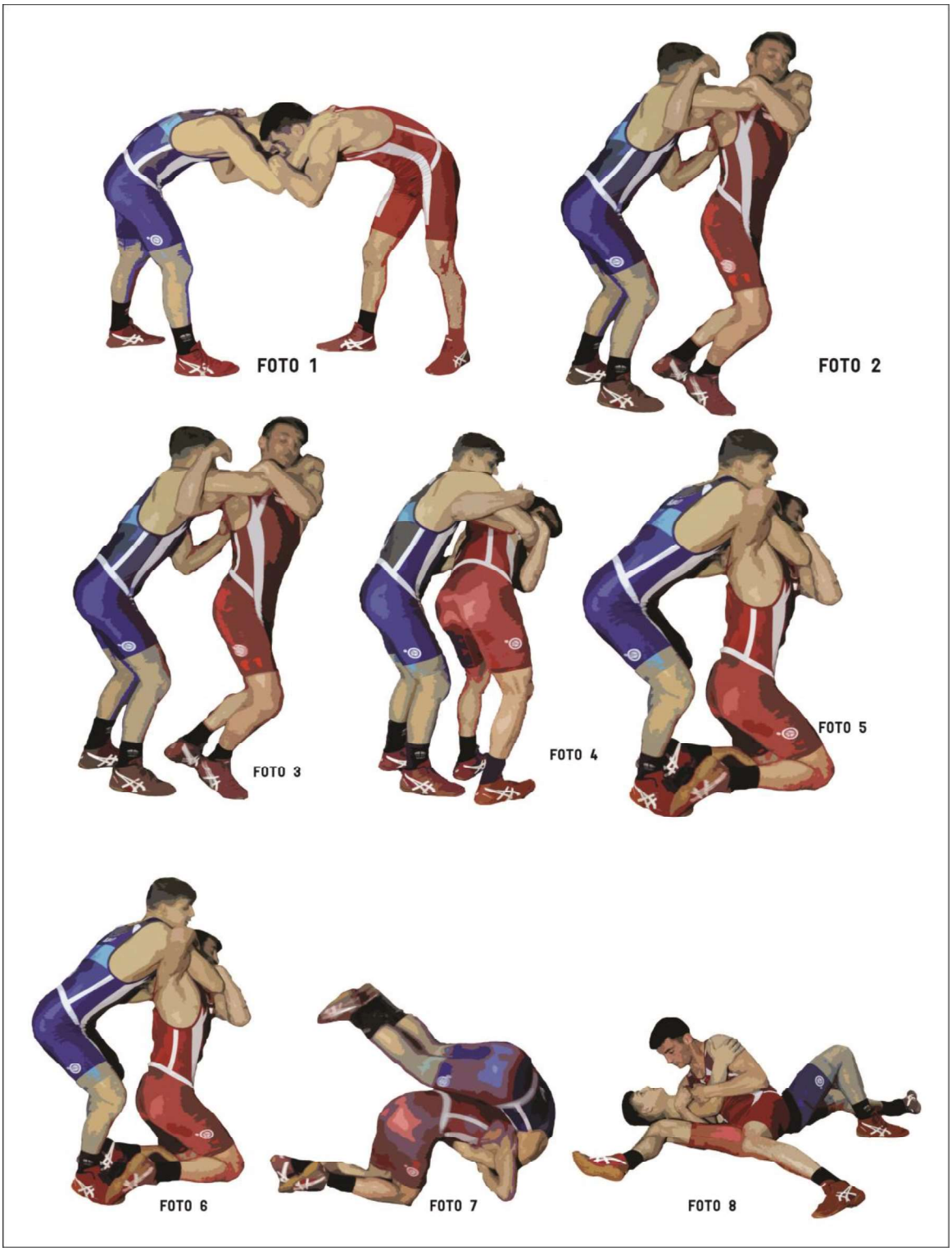


Figure 2. Phases (F1-photo 1, 2; F2-photo 3, 4, 5; F3-photo 6, 7, 8) of technique of shoulder throw –low variant



Indicators of the position of the body and its key parts during the first phase (imbalance of opponent) and second phase (establishing contact until the opponent is raised) on the three axes of the three-dimensional system are: right shoulder position, left shoulder, right thigh position, left thigh position, right knee position, left knee position, center of gravity of the body. The angles at the moment of the opponent's rise, namely the beginning of the opponent's flight (throw) phase are: right knee angle, left knee angle, right thigh angle, left thigh angle. The duration of the throw and throwing phases as a whole is also specified. The obtained values for the indicators in question were processed by the respective statistical methods of SPSS Package: descriptive statistics and t-test.

Results and Discussion

The position and displacement of the center of gravity and the joints of the wrestler's body, in the high and low variant of shoulder throwing technique, are crucial for successful throw. Table 1, presents data on the displacement of the athlete's body and important parts of the body while performing the high-variant and low-variant throwing technique. The position analyzed with the values given in table 1 is for the first phase of throw (the opponent's body imbalance) and for the second phase of grappling (opponent's body entrapment), in all three directions of the three-dimensional system: x- anteroposterior (front-back), y-mediolateral (left-right), vertical (top-down). The values of the statistical indicators are shown for the following variables: right shoulder position for both phases and all three directions (PSRXF1; PSRYF1; PSRZF1; PSRXF2; PSRYF2; PSRZF2), left shoulder position for both phases and the three directions (PSLXF1; PSLYF1; PSLZF1; PSLXF2; PSLXF2; PSLYF2; PSLZF2), the right hip position for both phases, and the three directions (PHRXF1; PHRYF1; PHRZF1; PHRXF2; PHRYF2; PHRZF2; PHRZ2; the left hip position for both phases and all three directions (PHLXF1; PHLYF1; PHLZF1; PHLXF2; PHLYF2; PHLZF2), right knee position for both phases and all three directions (PKNRXF1; PKNRYF1; PKNRZF1; PKNRXF2; PKNRZF2; PKNRZ; of the left knee for both phases and all three directions (PKNLXF1; PKNLYF1; PKNLZF1; PKNLXF2; PKNLYF2; PKNLZF2), as well as the center of gravity body of the wrestler performing the technique, for both phases and all three directions (PCGXF1; PCGYF1; PCGZF1; PCGXF2; PCGYF2; PCGZF2).

The comparison of the values of the variables analyzed between the two variants of throw is shown in Table 1. During the first phase of throw (imbalance), the position of the right shoulder in all three directions of the system (x, y, z) does not differ so much between the low variant and the high variant. Whereas during the second phase (full contact placement, grip of the opponent) the displacement of the right shoulder in the vertical direction - downward, is much greater in the low variant, so that it has high statistical significance ($p = 0.00$). The same thing happens with the position (displacement) of the left shoulder, where there is a significant difference between the two variants only in the second phase in the vertical direction - down ($p = 0.00$).

The position of the right thigh in all three directions of the system during the first phase of throw is with slight differences between the two variants. There is a significant difference between the two variants only in the vertical direction ($p = 0.052$), which means that wrestler during performance the low variant of throw, since the first phase (opponent's imbalance) entered its direction significantly lower than the high variant of throw. As the throw continued during the second phase, the body of wrestler, ie, his hip goes down even further, so that the difference between the two variants of throw on the vertical axis is even more pronounced ($p = 0.00$). The

results are similar for the left hip for both phases, comparing both variants of throw on the vertical axis.

Knee displacement during the first phase of throw is more pronounced in the anteroposterior and mediolateral directions, whereas in the vertical direction the displacement is understood to be smaller (table 1). But comparing and validating the differences between the two throw variants, shows that a more pronounced right knee displacement is in the lower variant during the second phase and this difference is highly significant (p = 0.00). Analysis and validation of the differences between the two variants of the throw for the left knee indicate that there are significant differences between the two variants: on the vertical axis during the first phase of throw (p = 0.026), with a more pronounced difference occurring during the second phase (p = 0.001), which means that the thrower drops the knees fully on the carpet during the low variant.

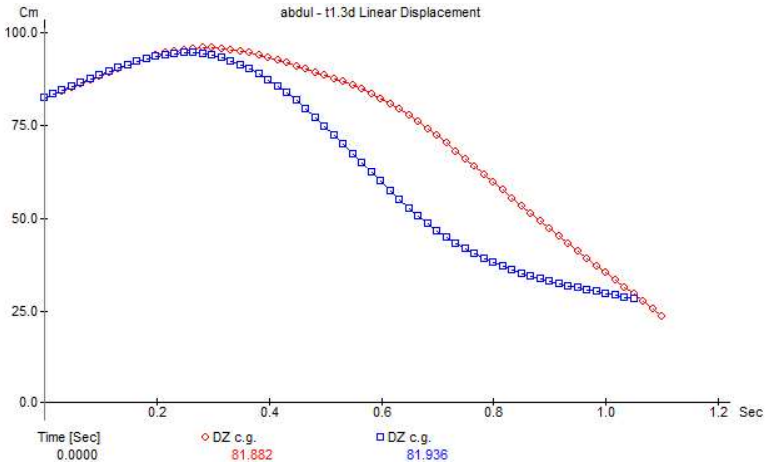
The center of gravity of the wrestler's body, during the first phase is greater displacement in the anterioroposterior direction, while in the other two directions the displacement values are much smaller. But during the second phase of the low variant when the thrower's body goes down further it is understood that the displacement value in the vertical direction is greater at the lower variant. Compared with the displacement value in this direction at high variant the difference is significant (p = 0.00), worth about 23 centimeters.

Table 1. Wrestler body position, side-throw technique - high variant and low variant

High side-variant casting	Mean	Std. Deviation	*Low side-variant casting*	Mean	Std. Deviation	T-test Mean Differen.	Sig. (2-tailed)
PSRXF1	30,9000	10,38642	PSDXF1	29,8000	8,96660	1,1	0,803
PSRYF1	14,8000	4,68568	PSDYF1	16,1000	7,80954	-1,3	0,657
PSRZF1	13,3000	3,68330	PSDZF1	15,4000	10,71033	-2,1	0,565
PSRXF2	13,5000	7,45729	PSDXF2	10,8000	6,21468	2,7	0,391
PSRYF2	22,8000	9,53124	PSDYF2	27,4000	10,24370	-4,6	0,312
PSRZF2	38,6000	9,16758	PSDZF2	62,6000	11,91824	-24	0
PSLXF1	10,2000	7,53953	PSMXF1	13,3000	7,77532	-3,1	0,377
PSLYF1	29,3000	5,39650	PSMYF1	29,1000	12,77541	0,2	0,964
PSLZF1	16,4000	3,74759	PSMZF1	14,8000	4,34102	1,6	0,389
PSLXF2	41,2000	10,80946	PSMXF2	45,1000	20,04135	-3,9	0,595
PSLYF2	39,7000	10,89393	PSMYF2	43,3000	15,25378	-3,6	0,551
PSLZF2	44,7000	5,98238	PSMZF2	65,6000	9,14330	-20,9	0
PHRXF1	63,3000	14,26768	PKDXF1	59,4000	14,13585	3,9	0,547
PHRYF1	20,0000	8,47218	PKDYF1	19,1000	7,68042	0,9	0,806
PHRZF1	9,6000	3,83551	PKDZF1	14,2000	5,82714	-4,6	0,052
PHRXF2	10,5000	6,63744	PKDXF2	14,2000	11,59310	-3,7	0,393
PHRYF2	13,0000	5,88784	PKDYF2	14,6000	6,53537	-1,6	0,572
PHRZF2	7,6000	5,27468	PKDZF2	33,7000	10,32849	-26,1	0
PHRXF1	54,8000	12,29092	PKMXF1	48,9000	10,80586	5,9	0,269
PHLYF1	24,5000	10,99747	PKMYF1	30,2000	11,98888	-5,7	0,282
PHLZF1	10,8000	3,67575	PKMZF1	16,3000	5,86989	-5,5	0,022
PHLXF2	27,4000	10,40513	PKMXF2	36,2000	15,49050	-8,8	0,153
PHLYF2	17,6000	5,98517	PKMYF2	20,1000	11,52244	-2,5	0,55
PHLZF2	7,1000	4,17532	PKMZF2	33,5000	11,31616	-26,4	0
PKNRXF1	67,8000	20,42765	PGJDXF1	61,6000	23,41035	6,2	0,536
PKNRYF1	33,6000	11,39396	PGJDYF1	37,4000	15,10850	-3,8	0,533
PKNRZF1	16,1000	5,66569	PGJDZF1	17,4000	5,79655	-1,3	0,618

PKNRXF2	11,7000	4,05654	PGJDXF2	14,6000	8,50098	-2,9	0,343
PKNRYF2	20,8000	10,79918	PGJDYF2	24,6000	19,08577	-3,8	0,59
PKNRZF2	9,3000	5,59861	PGJDZF2	27,9000	7,56380	-18,6	0
PKNLXF1	36,6000	14,88624	PGJMXF1	35,7000	18,25164	0,9	0,905
PKNLYF1	28,9000	16,21693	PGJMYF1	26,9000	12,54724	2	0,761
PKNLZF1	11,1000	4,14863	PGJMZF1	17,2000	6,79542	-6,1	0,026
PKNLXF2	43,6000	8,80909	PGJMXF2	39,6000	15,01259	4	0,477
PKNLYF2	15,1000	4,58136	PGJMYF2	19,0000	9,05539	-3,9	0,24
PKNLZF2	8,5000	4,69633	PGJMZF2	21,8000	9,85224	-13,3	0,001
PCGXF1	39,9000	10,62962	PQRXF1	36,5000	7,67753	3,4	0,423
PCGYF1	7,6000	4,99333	PQRYF1	10,7000	5,61842	-3,1	0,209
PCGZF1	9,2000	3,42540	PQRZF1	12,4000	3,65756	-3,2	0,059
PCGXF2	14,6000	6,14998	PQRXF2	19,6000	8,24891	-5	0,142
PCGYF2	9,6000	5,31664	PQRYF2	9,5000	7,56086	0,1	0,973
PCGZF2	19,8000	4,13118	PQRZF2	43,5000	8,30328	-23,7	0

Graph 1. The trajectory of the center of gravity (CG) movement on the vertical axis (z) in the high variant flank (red) and the low variant flank (blue).



The values for the duration of the phases in question are shown in Table 2. The duration of the first phase (F1-imbalance) in the high variant is approximately the same as the duration of this phase with the low variance. The duration of the second phase (F2-grasping the opponent's body) is longer in the low variant because the thrower, after returning the body to the opponent, continues to release his knee body toward the carpet. Whereas the duration of the third phase (F3-flight, throwing opponent) in the low variant is much shorter than in the high variant (significant difference $p = 0.001$) (table 2), because the thrower immediately kneels and rolls the opponent's body in the carpet. The total throwing time (TIMETO) is shorter than the low-variant cast. The stages of jumping are similarly divided to other jumps used in other sports, such as. in judo. Whereas in the freestyle wrestling, such divisions have also been made by other authors, but the difference is (Sinigovets, 2013).

Table 2. Duration of throwing by stages - high variant and low variant

High -variant throwing	Mean	Std. Deviation	*Low -variant throwing*	Mean	Std. Deviation	T-test Mean Differen.	Sig. (2-tailed)
TIMEF1	,4140	,04600	TIMEF1	,4160	,03748	-0,002	0,916
TIMEF2	,3180	,09355	TIMEF2	,3450	,07169	-0,027	0,478
TIMEF3	,4110	,07695	TIMEF3	,2950	,05104	0,116	0,001
TIMETO.	1,1430	,11490	TIMETO.	1,0560	,12020	0,087	0,115

Conclusion

The value of these indicators when moving the body for all three directions (x, y, z) is important information for the coach and for the athlete himself. The results of the kinematic parameters of the position of certain parts of the body for both variants of the throwing technique indicate the exits between the two variants in question. Each technique with its variants may not be equally applicable to all wrestlers. It depends on the type of wrestler's body composition, his motor and technical skills. Some of them with shorter body have the advantage of performing throwing technique. When this throw is done in the low variant it gives an additional advantage to the skill that is specializing in the technique. Depending on the results obtained during the performance, so can the training process with the aforementioned specifics for each wrestler. Experienced athletes know well that these techniques are highly productive in competitions.

Comparing the timing of throw as a whole in our study and other studies indicates that the results are very similar. The length of time a technique performs depends, among other things, on the momentary circumstances at the time of the throw, the quality of the athlete performing the technique, the athlete's style, the opponent's less or greater resistance, the athlete's goal during the throw (Minamitani et al., 1988). In real-life racing conditions during certain stages, especially imbalance and grip, other biomechanical factors are present that directly affect the duration (time) of the throw as a whole.

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