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BIOMECHANICAL ANALYSIS OF THE THROWING OVER THE CHEST TECHNIQUE IN WRESTLING

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Abstract: Understanding and preventing injuries in training is important for professional athletes. Cancellations of matches due to training injuries are a professional burden for both the injured athlete and their opponent. A well-structured training program, under proper supervision, can help prevent injury and improve athlete performance. The purpose of the study was the biomechanical analysis of the technique of throwing over the chest with the comparison of the execution of the technique by a novice fighter and an expert, while highlighting the risks of injuries in performing this technique in case of inadequate physical training. The study included an advanced fighter and a beginner fighter, for which images from the execution of the technique were compared and the differences were highlighted. The joint angles from different moments and the muscular activity during the execution were analyzed. The biomechanical analysis of the studied technique led to the highlighting of the muscles involved in the realization of this technique, the way of requesting them, the reange of motion required in the respective execution. Understanding and preventing injuries in training is important for professional athletes. Cancellations of matches due to training injuries are a professional burden for both the injured athlete and their opponent. A well-structured training program, under proper supervision, can help prevent injury and improve athlete performance.

Key words: throw, combat sport, injuries, prevention

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INTRODUCTION

Contact sports are a deeply rooted reality in today's society. Although the term ‘contact sports’ is generically assigned to those sports in which allowed or accidental contact between athletes occurs, it is most often associated with combat sports. These include classical sports such as boxing, wrestling, as well as sports branches of traditional martial arts such as judo, karate, taekwondo, jujitsu, wushu, etc.

It is relevant that in order to contribute to the quality increase of the training process, it is fundamental to develop new scientific knowledge regarding the sports technique, which should contribute constructively in the training process. With this context, scientific research in the field

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has expanded by studying the biomechanics of fighting techniques in order to understand the physical principles underlying their efficiency and to find the factors that influence performance.

The competition rules require athletes to compete with each other depending on their weight category. Some competitions require competitors to compete based on age, experience and gender. This not only allows more people to participate, but also reduces the risk of injury. However, injuries occur, especially to the knees, shoulders, skin diseases and blows to the head. Knee and shoulder injuries occur more severely than all other injuries and are the main injuries that require surgery, treatment and recovery (Jensen, 2017).

Studies show that the frequency of injuries is higher during training than during competitions (Rainey, 2009; AFHSC, 2014; Ziare et al., 2015; Lystad et al., 2015). Thus, Ziare (2015), in its study of 620 karate athletes, found that 90% of injuries were caused during training. Lystad (2015) conducted a study of 152 Australian taekwondo athletes and found that 81.5% of their injuries occurred during training (Lystad et al., 2015).

Hewett shows in his study about wrestling injuries that the injury rates increased with age, experience, and level of participation. The head, spine, trunk are the body region that incurred the greatest frequency of injuries, followed by the upper and lower extremities (Hewett et al., 2005). Some shoulder injuries occurring in wrestlers have been documented in a variety of case reports. Those include documented injuries to the suprascapular nerve, subscapularis tendon, sternoclavicular joint and avulsion fractures of the scapula and lesser tuberosity (Ross & Love, 1989; Berry et al., 1995; Brindle & Coen, 1998; Reddy et al., 2000).

Understanding and preventing injuries in training is important for professional athletes. Cancellations of matches due to training injuries are a professional burden for both the injured athlete and their opponent. All stakeholders (coaches, athletes, fitness trainers) should be encouraged to make more efforts to identify risk factors for injuries and to prevent injuries in training (Șarlă, 2015). A well-structured training program, under proper supervision, can help prevent injury and improve athlete performance.

Due to the complexity of most movements of the human body, imaging motion capture is the only method that provides the ability to capture all the data needed for a dynamic analysis of a specific activity over a long period (Winter, 2009). Although biomechanics for performance in sports studies the human body as a whole, many researchers focus on individual systems, such as the osteoarticular system, the muscular system, the nervous system, etc., applied segmentally (arm, leg). As a result, complex research is scarce or even absent. The strong point of computer modelling and simulation is that it provides real support for sports science, by providing research results that help to understand the performance of elite athletes (Bartlett & Payton, 2008). Specialized studies related to biomechanics in contact sports are very limited in terms of computer modelling and simulation. The modelling was applied for the analysis of impact situations, most models being dynamic, with finite or multibody elements.

The objectives of this paper were: biomechanical analysis of the technique Throwing over the chest and highlighting the risks of injuries in combat, especially in the execution of this technique, in order to contribute to improving the methodology used in preparation for contact sports.

MATERIALS AND METHODS

Participants

The study included an advanced fighter who has been practicing this sport for 15 years and a beginner fighter. The advanced subject (T.V.) practices Greco-Roman wrestling at a competitive level, being part of the national team Astra Arad and being national vice-champion in the 74 kg category. The trainings are with a frequency of 5 times a week, 2 hours each. The amateur subject practices this contact sport for pleasure, for 3 years, 3 times a week, without competitive purpose.

The characteristics of the subjects are presented in table 1. Both advanced and beginner subject training contain a physical training program and learning and improving sports procedures.

Table 1. General characteristics of the subjects

Subjects	Age (years)	Hight (cm)	Weight (kgf)	Years of practicing sports (years)
T.V.	29	175	73	15
S.C.	30	172	73	3

Description of the analysed wrestling technique – over the chest throwing

Jumps or throws over the chest are procedures related to the procedures of throwing over the hip. The characteristic of the procedure is the actions of the legs that create the turn, back towards the opponent. The group of throws over the chest includes some of the most important combat procedures. Chest throws or jumps are among the basic procedures of classical wrestling. The technique of execution of these procedures is complicated and difficult, due to the falls that are very heavy, both for the executor and for the opponent, which makes it even more difficult to master the technique of their execution. Therefore, in the sequence of learning the procedures, the jumps are on the last place, so they are taught only after all the other basic procedures have been mastered and only after the coach is convinced that the athletes he works with are thoroughly prepared and fit for the effort required at this learning stage.

The execution of the jumps starts from the position of guard, as follows: the performer, one leg to the front and the other to the back, brings the back leg closer to the front one, placing it parallel, on the same line, and at a distance of approximately 25-30 cm. After bringing the legs together, they remain bent at the knees. Simultaneously with the closeness of the legs, the trunk or the arms of the opponent are quickly fixed (the grips are different and multiple). From this situation, with the opponent well fixed, the actual execution of the procedure begins, to which the whole body contributes. The decisive action is that of the legs. They perform a sudden stretching action, the arms energetically pulling the opponent upwards, simultaneously with the fall of the performer on their back. Through these combined actions, the opponent is thrown energetically upwards and obliquely forward. In the current technical language, these procedures (throws over the chest) are called jumps. The differentiations are made according to the grips that are applied on the opponent (Cizmaș, 1988).

Biomechanical analysis of the technique

Analytically, the technique can be divided as follows:

Initial position: Poziția de gardă: Guard position: Stride standing in a sagittal plane, with the knees slightly bent, the trunk slightly tilt and the upper limbs in a slight triple flexion (prepared for gripping the opponent).

Time 1. Lowering the centre of gravity by knees flexion, bringing the back foot closer to the front by placing it on the same line with it, tilting the trunk and fixing the opponent's arms with grips on the arms, from the front (figure 1 & 2);

Time 2. Moving the centre of gravity below that of the partner, by trunk extension, bending backwards, hitting the partner's pelvis for momentum, height (figure 3 & 4);

Time 3. Throwing over the chest by twisting the torso, bringing the opponent below and maintaining the dominant position (control);

Final position: Fixing the partner holding the trunk, head or arm with the chest glued to it, legs slightly apart for stability, head up, chest out (figure 5 & 6).

By breaking down the throwing technique over the chest into analytical movements, the muscles involved in this technique can be highlighted.

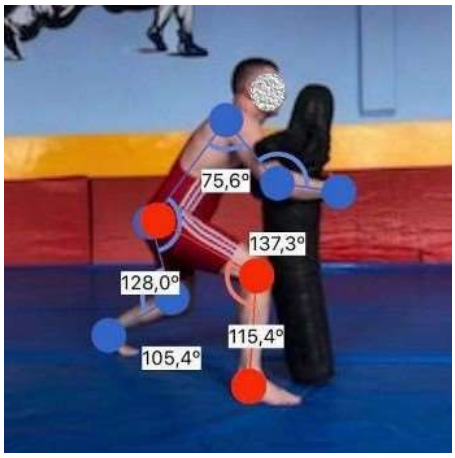

Figure 1. The subject S.C. - beginner, time 1 of technique execution execution

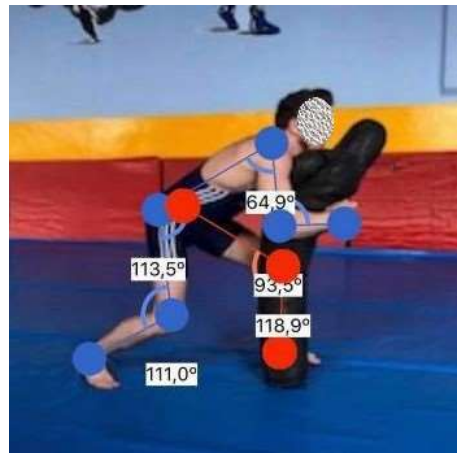

Figure 2. The subject T.V. - advanced, time 1 of technique execution

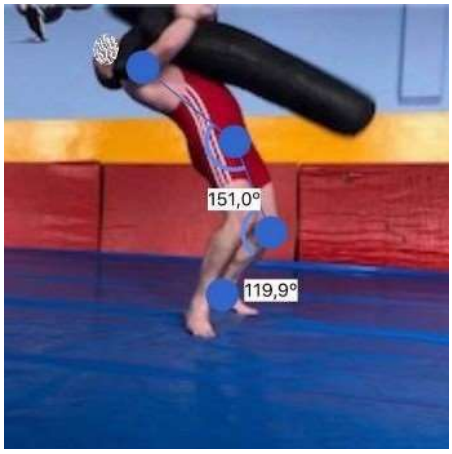

Figure 3. The subject S.C. - beginner, time 2 of technique execution

Figure 4. The subject T.V. - advanced, time 2 of technique execution

Figure 5. The subject S.C. - beginner, the final position of the technique

Figure 6. The subject T.V. - advanced, the final position of the technique

RESULTS AND DISCUSSIONS

From the tracing of the joint angles on images 1 - 6 it can be seen what is the amplitude of movement achieved by each subject during the execution of the technique. (tables 2 & 3).

Table 2. Comparison of the body segments segments positions during technique between beginner and advanced subject, at time 1 of technique execution

Joint	**Beginner**	**Advanced**
Shoulder	Flexed at 75.6°	Flexed at 64.9°
Trunk	Flexed at 30°	Flexed at 55°
Hip	Flexed at 45°	Flexed at 45°
Knee (anterior lower limb)	Flexed, angle between the thigh and the leg 137.7°	Flexed, angle between the thigh and the leg 93.5°
Knee (posterior lower limb)	Flexed, angle between the thigh and the leg 128.0°	Flexed, angle between the thigh and the leg 113.5°

Table 3. Comparison of the body segments segments positions during technique between beginner and advanced subject, at time 2 of technique execution

Joint	**Beginner**	**Advanced**
Shoulder	Flexed at 76°	Flexed at 80°
Trunk	Extended at 45°	Extended at 100°
Hip	Extended	Extended
Knee	Flexed at 45°	Flexed at 90°

From the comparison of the analyzed images and the angles measured at various moments of the technique, it can be seen that at execution time 1 which consists of entry and belting, the

beginner subject performs a lower flexion of the trunk on the pelvis and knee of the anterior lower limb, and the angle flexion of the arm on the trunk is higher than that of the advanced subject. This means that he raises his arms too high and does not move his center of gravity far enough forward and down (figure 7).

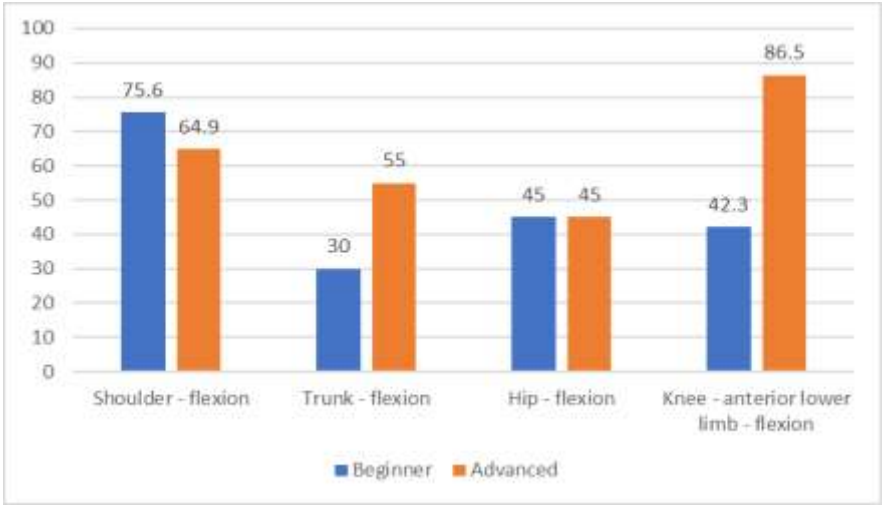

Figure 7. Comparison between the joint angles of the beginner and advanced subject, at time 1 of technique execution.

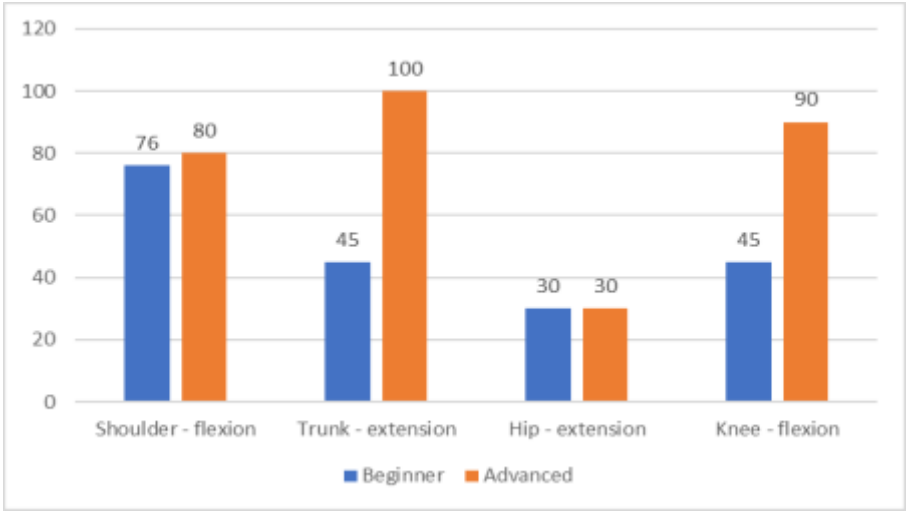

Figure 8. Comparison between the joint angles of the beginner and advanced subject, at time 2 of technique execution.

At time 2 of technique execution, which is the first part of the jump, the beginner subject performs a smaller extension of the trunk on the pelvis and flexes the thighs less on the calfs than the advanced subject. Thus, he uses much more energy and the technique may not succeed. Also, additional compensatory movements may be required, and these can lead to injuries (figure 8).

Table 4 shows the main muscles involved in each movement time of the throwing technique over the chest and their type of action during the technique. For a correct action of the technique, without performing compensatory movements involving other muscular and ligamentary actions, an adequate toning of these muscle groups is necessary.

Table 4. Muscle activity during the technique

Activity	Description	Muscles	Muscles activity
Initial position:	Stride standing in a sagittal plane, with the knees slightly bent, the trunk slightly tilt and the upper limbs in a slight triple flexion (prepared for gripping the opponent).	Quadriceps, lumbar extensors	Isometric contraction
		Anterior deltoid, biceps brachii, brachioradialis	Isometric contraction
Time 1	Lowering the centre of gravity by knee flexion, bringing the back foot closer to the front leg by placing it on the same line with it, tilting the trunk and fixing the opponent's arms with grips on the arms, from the front;	Quadriceps	Eccentric contraction
		Iliopsoas	Concentric contraction
		Right abdominal	Concentric contraction
		Anterior deltoid	Concentric contraction
		Shoulder internal rotators (Pectoralis major, latissimus dorsi, subscapularis)	Concentric contraction followed by isometry
Time 2	Moving the centre of gravity below that of the partner, by trunk extension, bending backwards, hitting the partner's pelvis for momentum, height;	Lumbar extensors	Concentric contraction
		Gluteus major	Concentric contraction
		Middle gluteus, hip adductors	Isometric contraction
		Triceps surae	Concentric contraction
Time 3	Throwing over the chest by twisting the trunk, bringing the opponent below and maintaining the dominant position (control).	Triceps surae	Isometric contraction
		Obliques abdominals, multifidus muscle	Concentric contraction
		Right abdominal	Isometric contraction
		Anterior deltoid, Pectoralis major, latissimus dorsi, subscapularis	Isometric contraction
		Hand flexors	Isometric contraction

The analytical analysis of movements and analysis of joint's angles show that a novice fighter, in order to perform and complete the technique, unless they have enough mobility and strength to perform the gripping and jump, tend to stress their joints in abnormal, compensatory positions, which will lead to a high risk of sprains and ruptures of the knee ligaments.

If the muscles of the knee, hip and torso are not toned enough, there will be an overload on the knee, which can lead to prepatellar bursitis.

One can observe from the movement analysis table that the trunk rotators play an important role in the jump during the technique. If they are not strong enough, a beginner will tend to force his shoulders, risking subluxation of the humeral head and damage to the tendons and ligaments in the shoulder girdle.

As can be seen in the analysis of the movements that make up the technique, another muscle with an important implication is the triceps suralis. Insufficient strength and a non-physiological stress on the ankle will lead to its sprain with soft tissue and ligament injuries to the ankle.

CONCLUSIONS

The purpose of the study was the biomechanical analysis of the technique of throwing over the chest with the comparison of the execution of the technique by a novice fighter and an expert, while highlighting the risks of injuries in performing this technique in case of inadequate physical training.

The biomechanical analysis of the studied technique led to the highlighting of the muscles involved in the realization of this technique, the way of requesting them, the reange of motion required in the respective execution.

The results of the analysis on photographs highlight large differences in joint amplitudes between a novice and an expert during the execution of the technique, which can be explained by insufficient strength of the muscle groups involved, insufficient joint mobility and / or incorrect acquisition of the technique. These weaknesses can most commonly have traumatic impacts on the knee through ruptures of the anterior cruciate ligament and sprains of the medial collateral ligament and prepatellar bursitis. Other effects of inadequate physical training are dislocation of the shoulder and sprains of the ankle. If the muscles of the knee, hip and trunk are not toned enough, there will be an overload on the knee, which leads to prepatellar bursitis.

To prevent these types of injuries, it is necessary for fighters to have in their physical training program, a series of exercises to increase the strength of the muscles that act on the knee and ankle targeted to increase the durability of ligaments and other connective tissues. Exercises to improve flexibility in these joints are also very important. In order to prevent shoulder dislocation during the fight, shoulder flexibility and strength exercises are required. Finally, yet importantly, exercises for training the trunk rotators should not be missing from the physical training program.

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