WHICH BODYPART OF A BASKETBALL PLAYER HAS THE LARGEST POSSIBILITY OF STRESS AND INJURY?

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1. INTRODUCTION

Professional athletes very often strain their muscular and musculoskeletal system. During competitions or an intense or more relaxed workout, their body performs a series of movements, which over time tend to lead to some injury.

In many cases, this injury is ultimately a chronic condition, leading to even greater physical and mental strain, but also (rarely) to early retirement of a professional career. There are many cases of important talented athletes (basketball and non-basketball players), who, despite their unparalleled talent, did not carry out the professional carrier they could. The reason for this was an injury, which did not allow the athlete to recover 100%.

This research, examining the main and at the same time the most frequent basketball moves in 5 athletes of different body type, aims to identify the most important and common body parts of injury, in order to give more importance to the prevention and proper recovery from such an injury.

2.BACKGROUND

Athletic biomechanics is defined as the biomechanics of athletic movements, i.e. the one that investigates the movements of the athlete's body, following his athletic effort. Its purpose is the effective application of the forces to achieve the target, after the creation of scientific data. Also, its basis is the achievement of the desired result of the athlete, after the least possible effort and effort. Usually the subject of study of athletic biomechanics are the movements of everyday life, the recovery of injuries and the achievement of athletic targets. It is based on the theory that all the movements that the human body can perform are intentional and useful, as the athlete always sets a target that he wants to achieve. From the above, the person (and in this case the athlete) tends to regulate his movements in such a way that all his activities are an organized whole.

Athletic force is an important factor for long-term success in sports. The best possible sport combines endurance, strength but also mainly optimal function of the musculoskeletal system. Over the years, more and more biomechanical approaches are used in training to improve performance and reduce the risk of injury to the athlete. The above approaches are based on the optimal function of the joints and muscles. For this purpose, biomechanical analysis systems are used to provide information on kinematics, kinetics and EMG. Research has concluded that biomechanical factors have a significant effect on the risk of injury and the "hidden" performance potential of the athlete. Essentially, the human body is a complex industrial system. In cases of defective biomechanics, there is an increased mechanical loading of the ligaments and muscles, while the relevant symptoms are difficult to detect and distinguish due to the compensatory actions.

Modern technology and the latest time methods allow analysis of biomechanical signals such as kinematic (motion), kinetic (force) and EMG. Biomechanical data can help identify the cause of joint and muscle overload during movement, but also select the appropriate training and treatment to avoid it. The above is based on the fact that optimal engineering leads to better performance and either significantly lower chances of serious injury, or less stress and therefore less power injury.

Important factors for optimal function are the best possible alignment of the joints, the intramuscular coordination, the strength of the joints, as well as the torque with the effects that they have on the bones, muscles and ligaments. Modern biomechanical methods are adapted for everyday use. They can help identify individual weaknesses and risk factors, which can help improve performance while reducing the risk, frequency and likelihood of injury.

3. EXPERIMENT PROCEDURE

The experimental process took place in July 2021 in a properly designed sports center, which was equipped with the necessary accessories. Specifically, SiMi software was used and 2D analysis was programmed.

The systems manufactured by SiMi concern the reception and analysis of motion and are based on high quality images, based on which a satisfactory profile of the behavior of the examined person can be created. These systems are based on a high-speed camera and use industrial image processing technology. Their purpose is to develop motion analysis technology, based on high quality images with a clear focus on user friendliness.

The experiment involved 5 basketball players, all of whom were healthy and without any injuries. This selection was made with the aim of highlighting the body parts that are as precarious as possible for injury, taking a sample from more than one athletes, who at the same time have different body types. More specifically, the body details of each athlete are given in Table 1.

Table 1: Body elements of each athlete

Element \ Athlete	1	2	3	4	5
Height (m)	1.98	1.96	1.90	1.99	1.70
Weight (kg)	98	100	85	83	72

Each athlete who took part in the experiment performed 6 different basic basketball moves, for which (via properly placed sensors) data were available on:

- Trunk angle
- Pelvis angle
- Valgus / Knee angle
- Hip angle

The basic movements that each athlete underwent during the experimental process were the following:

• 45º Cut - frontal left: The athlete is initially immobile with his hands in the back and in the most upright position possible. Then he starts abruptly accelerating dynamically, presses with his left foot on the plate and with his right "cuts" by 45º until his knee reaches its maximum possible flexion. The knee and hip sensors are placed on the left leg.

• 45º Cut - frontal right: It is the same procedure with the above movement with the difference that the pressing on the plate is done with the right foot and the "cut" with the left, until the knee of this foot reaches its greatest flexion. The sensors are placed on the right foot.

• Two legs hop - frontal left: The athlete is initially in the most upright position possible with his hands in his back, being on an "aerobic stepper". Then he moves and jumps with both feet. The sensors (knee and hip) are placed on the left leg.

• Two legs hop - frontal right: Same process of movement as above, with the difference that the sensors are placed on the right foot.

• Single leg hop - frontal right: It is the same procedure described for both legs, but the jump is performed with the right foot, on which the knee and hip sensors are placed.

• Single leg hop - frontal left: Corresponding procedure to the above with the difference that the jump is performed with the left foot, in which the sensors are placed.

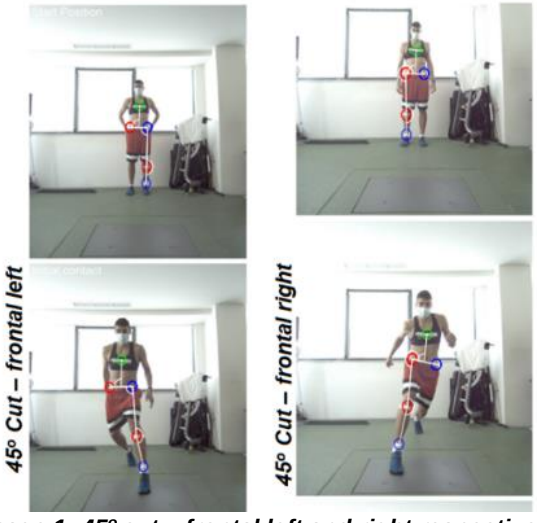

Image 1: 45º cut – frontal left and right respectively

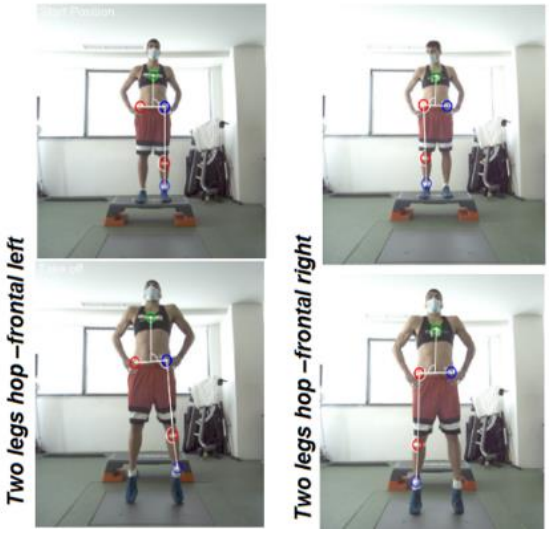

Image 2: Two legs hoop – frontal left and right respectively

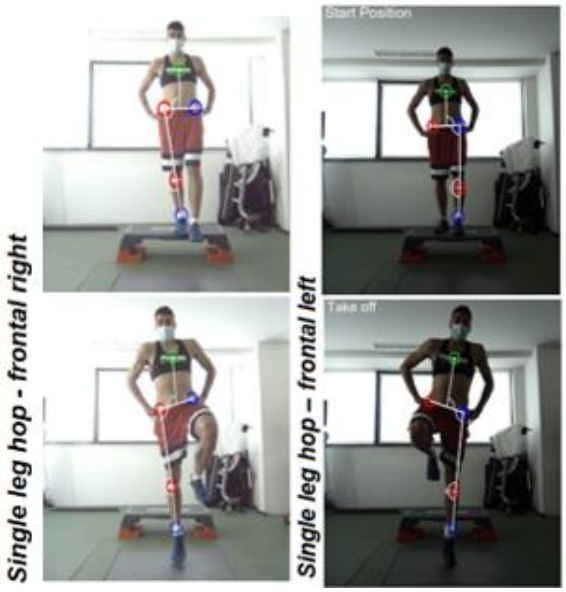

Image 3: Single leg hoop – frontal left and right respectively

It should be noted that the data for the aforementioned angles were taken during different moments of each movement and specifically for:

• The starting position (for Cut - frontal left & right movements)
• During the initial contact (for each movement)
• During the maximum knee flexion (for Two legs hop - front left & right and Single leg hop - front left & right movements)

For each of the above angles a target was given, which in case of satisfaction there is success of the effort, otherwise is failure. Specifically, the targets concern some of the moments of the movement and are illustrated in the following tables.

Table 2: Target of starting position

Angle	Target (º)
Trunk	<5
Pelvis	0
Valgus	<5
Hip	<2

Table 3: Target of initial contact for the 45º Cut - frontal left & right movements

Angle	Target (º)
Trunk	<5
Pelvis	0
Valgus	<8
Hip	<2

Table 4: Target of initial contact for the Two legs hop - frontal left & right and Single leg hop - frontal left & right movements

Angle	Target (º)
Trunk	0
Pelvis	0
Valgus	<5
Hip	<4-16

Table 5: Target of maximum knee flexion for the Two legs hop - frontal left & right and Single leg hop - frontal left & right movements

Angle	Target (º)
Trunk	0
Pelvis	0
Valgus	<8
Hip	<2

4. RESULTS

The previous chapter explained how to conduct the experimental procedure. This will list the results for all athletes and will highlight the parts of the body that need special attention. The first move to be considered is the 45º Cut - frontal left.

Table 6: Athletes results for the starting position (45th Cut - frontal left)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	<5	S	S	S	S	S
Pelvis	0	F	F	F	F	F
Valgus	<5	S	S	S	S	S
Hip	<2	S	S	S	S	S

From the above it is obvious that for the starting position all 5 athletes did not manage to achieve the target for the pelvis angle, in contrast to the targets of all the other angles.

The next movement moment that is examined is the moment when the athlete makes the initial contact and for which the results are presented through the following table.

Table 7: Athletes results for the initial contact (45º Cut - frontal left)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	<5	S	S	S	S	S
Pelvis	0	F	F	F	F	F
Valgus	<8	S	F	S	S	S
Hip	<2	S	S	F	F	S

Therefore, the table concludes that during the initial contact the level of difficulty in achieving the targets rises, as 3 of the 5 athletes failed to meet the target for two angles.

The next move studied is the 45º Cut - frontal right, for which the results are presented in the next two tables regarding the starting position and the initial contact of the athlete.

Table 8: Athletes results for the starting position (45º Cut - frontal right)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	<5	S	S	S	S	S
Pelvis	0	F	F	F	F	F
Valgus	<5	S	S	S	S	S
Hip	<2	F	F	S	S	S

With the previous move, it is observed that the first two athletes, in addition to the target for the pelvis angle, did not manage to achieve the target for the hip angle. Respectively for the initial contact it is observed that not all the athletes managed to meet the target for at least two angles.

Table 9: Athletes results for the initial contact (45º Cut – frontal right)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	<5	S	S	S	S	S
Pelvis	0	F	F	F	F	F
Valgus	<8	F	F	S	S	S
Hip	<2	F	S	F	F	F

Next movement under consideration is Two legs hop - frontal left. The following two tables refer to the results obtained for the initial contact and for the moment of maximum knee flexion.

Table 10: Athletes results for the initial contact (Two legs hop – frontal left)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	S
Pelvis	0	F	F	F	F	F
Valgus	<5	S	F	S	F	S
Hip	<4-16	S	S	S	S	S

Table 11: Athletes results for the maximum knee flexion (Two legs hop – frontal left)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<8	F	F	S	F	F
Hip	<2	F	F	S	F	S

From the tables it is observed that for this move the most failures were recorded, compared to the two previous moves. This can be reflected in the fact that no single target was achieved by all athletes. Of course, even in this case, most of the failures were related to the target for the pelvis angle.

Then follows the Two legs hop - frontal right movement. The results given in the following tables show that the target for the pelvis angle has not been achieved. Regarding the targets for the other angles, it is observed that during the initial contact there is absolute success in the valgus angle and hip angle targets.

Table 12: Athletes results for the initial contact (Two legs hop – frontal right)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<5	S	S	S	S	S
Hip	<4-16	S	S	S	S	S

Table 13: Athletes results for the maximum knee flexion (Two legs hop – frontal right)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<8	F	F	S	F	F
Hip	<2	F	F	S	F	F

The analysis continues with the Single leg hop - frontal right movement, for which the following two tables are listed for the initial contact and the maximum knee flexion.

Table 14: Athletes results for the initial contact (Single leg hop – frontal right)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<5	S	S	S	S	S
Hip	<4-16	S	S	S	S	S

Table 15: Athletes results for the maximum knee flexion (Single leg hop – frontal right)

Angle	Target (º)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<8	S	F	S	F	F
Hip	<2	F	F	F	F	F

Apart from the fact that the target for the pelvis angle was not achieved, it is observed that the results, regarding the final result of success or failure, are align with those that emerged for the Two legs hop - frontal left & right movements.

Finally, the results regarding the Single leg hop - frontal left movement, for which the conclusions, compared to the movement Single leg hop - frontal right, do not change significantly.

Table 16: Athletes results for the initial contact* (*Single leg hop – frontal left)

Angle	Target (°)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<5	S	F	S	S	S
Hip	<4-16	S	S	S	S	S

Table 17: Athletes results for the maximum knee flexion* (*Single leg hop – frontal left)

Angle	Target (°)	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5
Trunk	0	F	F	F	F	F
Pelvis	0	F	F	F	F	F
Valgus	<8	S	S	S	S	F
Hip	<2	F	F	F	F	F

From the above tables, 3 new summary tables can emerge, in which the success rate of the specific target is written for each examination moment and for each angle.

Table 18: Aggregate success rates of athlete targets for the starting position

Angle	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5	Sum	Sum(%)
Trunk	2/2	2/2	2/2	2/2	2/2	10/10	100
Pelvis	0/2	0/2	0/2	0/2	0/2	0/10	0
Valgus	2/2	2/2	2/2	2/2	2/2	10/10	100
Hip	1/2	1/2	2/2	2/2	2/2	8/10	80

Table 19: Aggregate success rates of athlete targets for the initial contact

Angle	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5	Sum	Sum (%)
Trunk	2/6	2/6	2/6	2/6	3/6	11/30	36.7
Pelvis	0/6	0/6	0/6	0/6	0/6	0/30	0
Valgus	5/6	2/6	6/6	5/6	6/6	24/30	80
Hip	5/6	6/6	4/6	4/6	5/6	24/30	80

Table 20: Aggregate success rates of athletes for maximum knee flexion

Angle	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5	Sum	Sum (%)
Trunk	0/4	0/4	0/4	0/4	0/4	0/20	0
Pelvis	0/4	0/4	0/4	0/4	0/4	0/20	0
Valgus	2/4	1/4	4/4	1/4	0/4	8/20	40
Hip	1/4	0/4	2/4	0/4	1/4	4/20	20

From the above summary tables it is observed that during all the movements, the moment when the targets for the examined angles cannot be achieved is that of the maximum flexion of the knee. This finding is made by observing the success rates of the respective objectives. As mentioned above, the target of pelvis angle was not achieved in any effort of any athlete. However, during the maximum knee flexion, there was a significant drop in the success rates of the requested targets.

The last part of the analysis concerns a summary table, which presents the total success data for each angle, regardless of the moment of movement.

Table 21: Final aggregate success rates of athletes

Angle	Athlete 1	Athlete 2	Athlete 3	Athlete 4	Athlete 5	Sum	Sum (%)
Trunk	4/12	4/12	4/12	4/12	5/12	21/60	35
Pelvis	0/12	0/12	0/12	0/12	0/12	0/60	0
Valgus	9/12	5/12	12/12	8/12	8/12	42/60	70
Hip	7/12	7/12	8/12	6/12	8/12	36/60	60

The above table makes it clear that the most dangerous and precarious - for injury- part of an athlete's body is the pelvis. The fact that out of a total of 60 attempts, in each moment of movement, none was within the intended target, can be considered worrying. The next bodypart that is dangerous for injury is the trunk. This observation results from the overall percentage, which is low due to the low success rate of the targets during the initial contact and the maximum knee flexion. However, at the starting position the percentage is the absolute one for each athlete, a fact which does not cancel the previous observation.

Regarding the hip angle and valgus angle, their percentages are not so worrying, especially for the valgus angle. During the starting position and the initial contact, the success rates of the valgus angle target are high for all athletes, with the value of the final average decreasing due to the results during the maximum knee flexion. Finally, regarding hip angle, its percentages can in no way be considered low, nor high. The average is reduced after including in it, the success rates during the maximum knee flexion, which are very low. In contrast, the success rates at the starting position and the initial contact are quite high, thus maintaining an acceptable value on average.

5. CONCLUSIONS

1) From the 2D analysis it appeared that, in the movement "45º Cut - frontal left" both at the starting position and at the initial contact position the target for the pelvic angle could not be achieved by any athlete. On the contrary, the target for the trunk angle was achieved by all the athletes, without any failure in any effort. Also, in most cases, the target for the valgus and hip angle were achieved, although there were several failures. For this move overall most targets (at equal values) were achieved by athletes 5,1 and 3.

2) Regarding the movement "45º Cut - frontal right" there were failures in all angle targets, since there was no angle target to be achieved by all athletes. In addition, in general, target failures were higher during this move, while most successful target achievements were recorded by athletes 5 and 4.

3) For the movement "Two legs hop-frontal left / right", i.e. for a total of four efforts of each athlete, there was particular difficulty in achieving the target for the trunk and pelvis angles both during the initial contact and during the maximum knee flexion. For the above two angles, all the efforts of all the athletes were totally unsuccessful. Regarding the valgus and hip angles, their targets were achieved significantly more times during the initial contact compared to the maximum knee flexion. For this move, by far the athlete, who had the most target successes, is the athlete 3.

4) For the movement "Single leg hop - frontal right", regarding the angles of the trunk and pelvis, the same was found in the previous analysis (movement "Two legs hop - frontal left / right"), but it was also observed that the target for the hip angle during maximum knee flexion was not achieved by any athlete effort. In general, from the results, it was concluded that again athlete 3 scored the best performance, ie he had more success of angle targets.

5) Finally for the "Single leg hop - frontal right" movements, it was observed again that the targets for the trunk and pelvis can not be achieved by any athlete in cases of initial contact and maximum knee flexion, while the target for the hip angle in the second case could not be achieved. From the results, it was found that the best performance (most successful angle targets) was recorded by athlete 1.

6) From the aggregate results it is observed that the moment of max knee flexion movement can significantly strain the athlete's body and is the most feared moment for injury. Correspondingly, the moment when the body is less loaded is that of the starting position.

7) The most unsafe - for injury- part of the body is the pelvis, for which no athlete and at no time achieved the predetermined target. The second most unsafe bodypart, according to the overall results, is the trunk, for which, however, the danger does not exist at the starting position except unexpectedly.

8) On the contrary, valgus and hip are the least unsafe parts of the body for injury and especially the first of them, for which the success rates are satisfactory. However, in the event of an injury to that particular part of the body, then it will occur during the maximum knee flexion. Finally, regarding the hip, the success rates are moderate to acceptable and the case of injury has chances only during the maximum knee flexion.

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