ANALYSIS OF BIOMECHANICAL ABILITIES OF BASKETBALL PLAYERS THROUGH THE USE OF A K-TRACK DEVICE

Riccardo Izzo and Michael Bertoni

School of Health and Sport Science, DISB, University of Urbino Carlo Bo, Italy

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Abstract

The recognition and the assessment of biomechanical abilities through inertial devices can provide important information about physical parameters and functional capabilities of basketball athletes. These capabilities, which were evaluated by the technical staff's eye and the trainer until recently, are now assessed directly, through the data acquisition during the whole exercise execution. In this paper, we propose an evaluation study of biomechanical abilities of basketball athletes through the use of an innovative device, the K-track, which contains inside of it an accelerometer, a gyroscope and a magnetometer, and it's able, through the inertial movement technology, to detect the player's movements with a frequency of200 Hz. It was also possible to recognize and link some typical movement of the sport to determined data of the device. Future use and development of the K-track aim to the creation of a software able to recognize the athlete's movement and define the degree of execution, allowing an increasingly deeper real time qualitative analysis of this sport.

Key words: *K-Track, inertial devices, basketball, qualitative analysis.*

Introduction

The Biomechanics is the study of the structure and the functioning of Biological systems, through the usage of mechanics (Hatze, 1974). Biomechanics is the study of the application of mechanical laws to living organisms, and it uses leverage and vectors as tools for human's movements study. A peculiar branch of biomechanical is the biomechanical in the sport, which studies the human body movement during the physical exercise, and analyses the mechanical and biological causes of the movement itself. The goals which biomechanical studies have in the sport are not limited to the study of structure, properties and motoric functioning of the athlete's body, but comprehend also the study of executive techniques and individual characteristics compared to the performance. For our research we focused on a biomechanical analysis of the basketball game; in this sport gestures and movements required to carry out with precision the motoric task are the fundamentals, individual and collective. The execution of a motor task is accomplished based on the biomechanical qualities of the player's locomotor system and the ways the player uses to perform the motor task constitute the individual execution technique. The goal of biomechanics in basketball is to establish the best way to carry out motor tasks through a functional, economical and profitable movement. It is precisely in the intention to carry out this study that we relied on the match-analysis, which is the data-gathering method which, through scientific and statistical survey, allows to evaluate objectively the physical and technical-tactical performance of the single Athlete, or an entire team. This system, subject of several studies (Izzo, 2010; Marcolini, 2010; Sacripanti, 2000; 2007; Sarmento, 2014; Carling, Nelson & Bradley, 2014), transforms the performance model into a mathematical math that allows us to analyze and objectively and best match players and improve them through a more targeted workout, like the studies of Ruosi (2007) and Marcolini (2011) explain. Our study was conducted with the aim to assess, through preliminary tests, the balance and stability, acceleration and deceleration capabilities of some basketball players participating in the under 20 national championship; high intensity activities as those analyzed by Di Salvo et. Al. in their study in 2009 and at intermittent frequency during the game, like those analyzed, in football, by Ohashi, Miyagi, Nagahama, Ogushi and Ohashi (2002).

These qualities are indispensable for performing properly and in the best way any movement within the playing field, from simple running, to different types of jumps, till coming to slides and more complex technical gestures. Our goal is to recognize patterns, models and recurring schemes; to recognize which data the sensors used provide us when a particular movement is performed: a jump, a squat, rather than a close-out run. Moreover, after we have allocated certain moves to each set of data, the goal was to provide with the data on the performance of the athletes in question, a benchmark which we will be able to use to compare the performance of other athletes in the future. Until now, the athlete's physical condition was mostly attributed to the eye of the athletic preparatory technical staff or some indirect tests which allowed data to be obtained and evaluated only taking into account the final result of the test itself. For example, in the Sargent Test, the explosive acid power and the explosive-elasticity of the lower limbs is evaluated exclusively using as a parameter the simple athlete's height jump (in cm) detected at the end of the test.

This measure is then inserted into a formula [Formula Lewis: Power = v4.9 x body weight (kg) x jump height (m) x 9.81], resulting in a evaluation of the subject under consideration. Anyway, neither the test nor the operators, allow us to obtain real-time numerical data, and therefore to evaluate the player's performance throughout the course of the exercise. However, in our study, thanks to the use of the K-Track device as a scientific approach to the evaluation of basketball players, it was possible to capture data during the entire run of the exercise, allowing us to work on a range of complete data, taking into account all stages of the test and not just the final result, leading us to a new and far more in-depth evaluation of the player

Devices and methods

The K-track device

During the last decades, many progress have been made about the application of technology for the study of sports performance, like Liebermann, Katz, Huges and Barlett et. al.(2010) describe us in their study. GPS and micro sensors are used in many team sports (Holzer, Hartmann, Beetz & Von der Grun, 2003; Alberti, Fiorenza, Borges & Coutts, 2014), as for example rugby (Housler, Halaki & Orr, 2015). The device, used by us in the world of basketball, the K-Track, designed by K-Sport International, is nothing but a device that contains a new generation inertial measuring system capable of tracking player movements at a real frequency of 200 Hz. Inside we can find, a 3D accelerator 16G 200 Hz, a 3D 200 Hz gyroscope, and a 3D magnetometer 200 Hz, it weighs 25g and measures 70x20x7 mm. Accelerometers are tools that can be worn in various parts of the human body of the subject and measure the acceleration of a given body segment in the three dimensions.

Gyroscopes are transducers capable of converting angular velocity into an electrical signal, and they can be fixed to anybody segment to achieve the time course of its angular velocity. All gyroscopes used for movement analysis are made of vibrant mass and are particularly suited to the purposes of motion analysis for costs reasons (low-cost), dimensions (small), and power consumption (low).

Magnetometers are instead sensors capable of generating potential differences depending on the magnetic field to which they are subjected, so the output electrical signal will be proportional to the intensity detected by the magnetic field. K-Sport International has tested all types of accelerometers, gyroscopes and magnetometers available on the market and has selected the most suitable for research purposes. All three inertial sensors are triaxial, thus providing data on all three axes (x, y & z).

The device is absolutely non-invasive and comfortable to wear: thanks to a special belt can be positioned anywhere in the body and is able to monitor the movement of all bone and kinetic segments.

The system is able to analyze all state-of-the-art parameters and other experimental variables, such as:

- ✓ 3D acceleration;
- ✓ 3D speed;
- ✓ direction;
- ✓ power;
- ✓ body balance;
- ✓ gait analysis;
- ✓ running analysis;
- ✓ jump analysis (ex. squat jump).

The K-Track can be connected to the PC as a common USB flash drive allowing instant data transfer. In addition to this, all the raw data are available, it has the ability to set the data acquisition frequency of the sensors and their sensitivity and can be also used to monitor the movements of any body segment.

Figure 1. K-Track Device (Credits: K-Sport International, ITA)

Test protocol

Our study was based on preliminary tests for the evaluation of players in terms of balance and stability, acceleration and deceleration. The device, containing the inertial sensors, was inserted in the appropriate support band and placed on the back of the athletes at the height between the T6 and the T8 (dorsal vertebrae), ensuring the best possible solidarity of the axes of the device with the anthropometric axes. Before starting the tests, some data relating to the athletes in question were collected, such as weight, height, age and leg predisposition (main leg, which the athlete preferably uses to perform actions such as kicking a ball or performing a monopodal detachment; for the predisposition leg we mean the lower limb with which the player performs these gestures more effectively and we distinguish it from the non-predisposing leg, the lower limb lesser used by the player). In addition, the *Ankle Dorsiflexion test* and *Sit and Reach* tests were used for anthropometric evaluation of athletes and a subsequent standardization for a comparison between them. After this phase, we passed to the preliminary tests though the use of the K-Track device, for the evaluation of the players in terms of balance and stability. During this phase of the protocol, after the activation of the device, the athletes placed their hands at the height of the hips and kept them in that position for the whole duration of this test's phase. After being left stationary for 5 seconds, the athletes raised their predisposition leg, making a 90 ° angle, remaining in that position for 10 seconds. After that, they rested their leg back in the bipedal position for 5 seconds, lifting then the leg of non-predisposition, by doing a corner of 90 degrees for 10 seconds. Returning to the bipedal position and waiting for 5 seconds, they then raised the predetermined leg for 10 seconds, at the end of which they returned to the bipodal position and immediately raised their non-predisposed leg for 10 seconds (this last movement was repeated twice). In the next phase of the protocol, the acceleration and deceleration capabilities of the players in question were evaluated. Those capabilities were already processed subjects in several studies (Akenhead, Hayes, Thompson & French, 2012; Dalen, Ingebrigtsen, Hjelde & Wisloff, 2016; Izzo & Soppranzetti 2016). The athletes then were placed on the starting line with the arms in the side opening position (indicated by the preparator), activated the device and expected 3 seconds, it was asked them to make a 5-meter sprint with a close-out finishing (a typical basketball movement where a defender reduces the distance between himself and a ball striker in an attempt to disturb a shot, prevent a pass or a basketball penetration). They then took 3 seconds in that position and returned walking to the initial position (this test was performed 3 times). Finally, the last phase of the protocol provided an initial sprint (on a 10 meters distance), a direction change, and a further sprint to return to the initial position.

Results

Before explaining the results of the tests performed with the K-Track device, the following tables show firstly the collected data, which were then used for the anthropometric evaluation of the athletes and a subsequent standardization for a comparison between them: Regarding Phase 1 of the test protocol, we were based on the data provided by the accelerometer inside the device. Evaluation of athletes' stability was based on the analysis of acceleration threshold values (on x, y & z axes) and the time required to recover stability after performing predefined movements. The data is shown in the following tables:

Table 1. Stability threshold (m/s^2).

	STABILITY THRESHOLD (m/s^2)		
	Threshold value Z axis	Threshold value Y axis	Threshold value X axis
Athlete n. 1	+ 0,7 respect to the non-constant regimen value	+- 0,3 with regime 0	+- 0,5 respect to the non-constant regimen value
Athlete n. 2	+ 0,5 respect to the non-constant regimen value	+- 0,5 with regime 0	+- 0,6 respect to the non-constant regimen value
Athlete n. 3	+ 0,4 respect to the non-constant regimen value	+- 0,5 with regime 0,25	+- 0,5 respect to the non-constant regimen value
Athlete n. 4	+ 0,4 respect to the non-constant regimen value	+- 0,3 with regime 0	+- 0,5 respect to the non-constant regimen value

Table 2. Stability recovery times (s).

	Stability recovery times (s)					
	Mov.1	Mov.2	Mov.3	Mov.4	Mov.5	Mov.6
Athlete n. 1	3,91	2,38	1,8	2,64	5,69	5,39
Athlete n. 2	5,3	5,28	6,52	8,35	5,56	4,11
Athlete n. 3	4,91	8,86	6,93	6,78	6,31	4,13
Athlete n. 4	3,42	4,56	5,47	2,49	4,21	6,03

Table 3. Deceleration peaks (m/s^2).

	DECELERATION PEAKS (m/s^2)		
	Sprint n. 1	Sprint n. 2	Sprint n. 3
Athlete n. 1	14,24	8,66	13,14
Athlete n. 2	6,31	10,46	9,56
Athlete n. 3	12,72	17,84	17,38
Athlete n. 4	7,42	12,22	13,98

By threshold value is meant the mean value of data, with low standard deviation, which thus identifies a situation of steady position and absence of movement, therefore a stability situation (in our case, raising a leg and maintaining the position assumed). After exceeding the threshold value, the player will start exercising and increase his degree of instability, from a bipedal support to a monopedal support.

The acceleration values on all three axes begin then to oscillate, giving us important insights on the athlete's stability during exercise. The values found on the X axis indicate right side (positive values) or the left side (negative values) accelerations, thus representing a lateral oscillation of the player; on the Y axis, the values conduct to an upward (positive) or downward (negative) acceleration, while on the Z axis we can recognize the m/s^2 movement followed by the device forward (negative values) or backward (positive values). On the X and Z axes, the regime value (acceleration value found when the player is stationary, waiting to start the exercise) is not constant, while on the Y axis it approximates about 0 in all athletes analyzed. These non-constant regime values on the X and Z axes may be due to a shift of the device during the movement, or to a different inclination of the boy after the movement, so we have the influence of 1G which is redistributed on the 3 axes in a different way. On the Y axis, the regime value in all the athletes is approximately around 0 m/s^2, because there are no marked movements on this axis (such as a jump), the feet remain attached to the ground and the acceleration value returns always around 0 after the movement. From the study of the data in the previous tables, derived from the graphs shown at the end of this stability analysis, we have been able to obtain threshold values with respect to the non-constant regimen value ranging from +0.7 m/s^2 to +0.4 m/s^2 on the Z axis and from + - 0.5 m/s^2 to + - 0.6 m/s^2 on the X axis. On the Y axis we have found values ranging from +/- 0.3 m/s^2 to + -0.5 m/s^2 with a regime value approximately around 0 for all athletes (in graphs the regime value is around 10 because it has not been subtracted 1G = 9.81 m/s^2 which corresponds to the presence of earth's gravity, which acts continuously on the device. These values give us important assessments of player stability, because low variations between the threshold value and the regime value can mean that the movements on the three axes analyzed were minimal, so the athlete remained quite fixed and did not generate high peaks of acceleration, showing good stability (as in the case of athlete n.4).

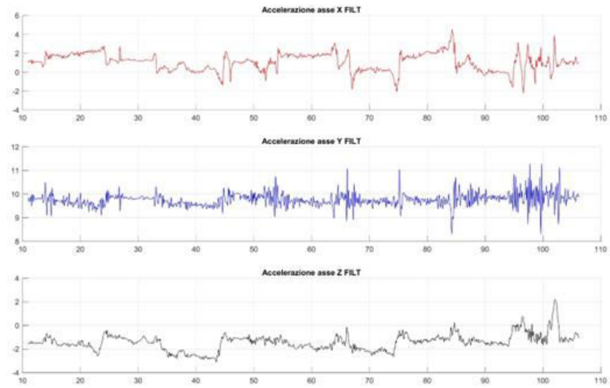

Figure 2. Acceleration

High variations between the threshold value and the regime value would mean a greater movement of the athletes on the three axes in an attempt to recover balance after the movement was performed, thus denoting a worse stability (as in the case of athlete n.2).

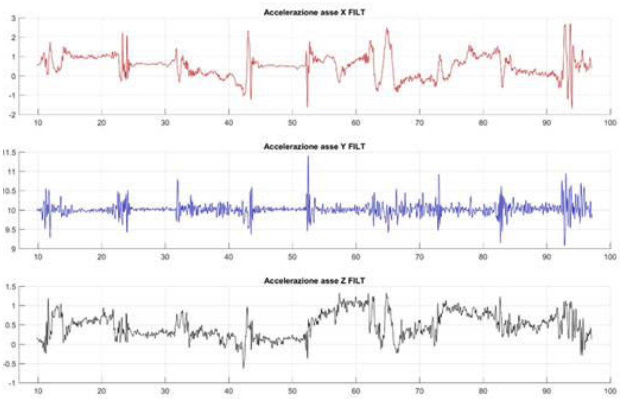

Figure 3. Athlete n. 2 stability graph (observe high peaks of acceleration, that show a worse stability than the athlete previously analyzed).

In addition to the threshold values, in this assessment of athletes' stability, we also analyzed the recovery times of stability, that is, the times (expressed in seconds) on which players recovered after being moved from a bipodal to a monopodal position. These times, given in the previous table, give us important insights about stability of each athlete in question and about his ability to restore balance after performing the movements indicated by the protocol. Taking a look at the charts below, we can notice the differences between athlete n.1 (higher variations values between threshold values and higher regime values, but lower time values in stability recovery) and athlete n.3 (lower variations between threshold values and regime values, but longer recovery times).

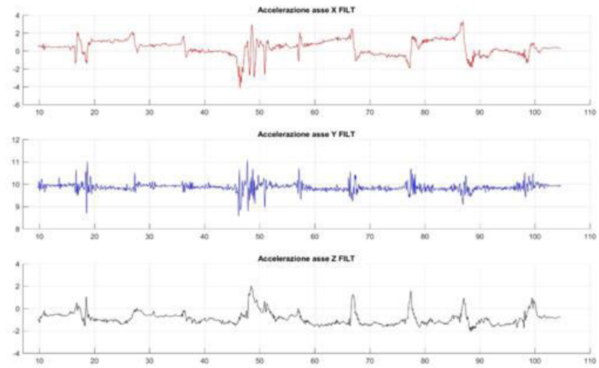

Figure 4. Athlete n. 1 stability graph (observe high variations between the threshold value and the regime value and good stability recovery times after performing the predefined movements)

The second main issue to be evaluated through these tests is the ability to accelerate and decelerate of analyzed athletes during the run, subjects already analyzed in several studies in the past (Di Prampero, Fusi, Sepulcri, Morin, Belli & Antonutto, 2005; Izzo & Lo Castro, 2015; Izzo & Morello Zenatello, 2016).With the help of the test protocol and the chart below, which illustrates the data collected by the accelerometer inside the device (on athlete n.4), we have been able to recognize the movement of the run (also analyzed by Buchheit, Mendez-Villanueva, Simpson & Bourdon in 2010), typical movement that has very little peaks on the X and Y axes (around + - 10 m/s^2), while it presents the most marked peaks on the Z axis, being the latter, the actual axis on which the movement is performed. During the run, the peaks repeat at a high frequency, unlike the walk, during which (as can be seen in the graph below) the peaks have a lower intensity and frequency. The chart below shows the data captured by the K-track device during the protocol phase in which the athlete (in this case the n.4) alternates twitch on a 5 meters distance with finalclose-out, to a walk, always on the same distance, to go back to the initial position. In this phase of the protocol, in addition to the recognition of the travel movement through the collected data, we have been able to analyze the close-out, typical basketball movement consisting in a run with a final freeze in the balance, which it is much used in recovery situations on a striker with the ball. Analyzing the charts we were able to notice that during the close-out the athletes exceed an average threshold value of $10 m/s^2$ on the Z axis, on average. However, this can be confusing because even during the run the threshold value is exceeded by $10\ m/s^2$. Anyway, the graph below, gives us an important indication: the close-out may average around a $10m/s^2$ variation on the Z axis, but to be considered a good close out, the peak values on this axis must exceed $13\ m/s^2$, as in the close out of athlete n.3. In this sense, the obvious differences between the latter athlete and others can be attributed to the different attention and commitment made during the tests.

In performance, in fact, the emotional factor, like for example anxiety, is very much affected (Raiola, Gomez Paloma & Altavilla, 2015), and there is a need for a high number of repetition of the gestures that will be analyzed (what did not happen in our tests), to allow the athlete to make their own each movement and express themselves to the maximum of their possibilities in movements already learned. An analysis of these deceleration peak data on the close-out movement led us to an assessment of the ability of the athlete to decelerate, which, transferred to a realistic gaming situation, can be related, for example, to the ability in arrive faster to contest an opponent's shoot.

With higher deceleration peaks we can make a more effective close-out. In order to better compare the athletes each other, considering that they have different physicalities and characteristics, we have used the standardization process, using anthropometric data collected initially. In fact, by multiplying the mass of the subject by the acceleration value expressed in the peak, we get the expressed force that is no longer a subjective athlete's value (as is the acceleration) but an objective value, therefore comparable with the force expressed by the other athletes.

[F = m x a]

Calculating the average force expressed by the athletes in the course of three sprint on a 5 meters distance, we obtained the following values:

- ✓ Athlete n. 1: 1224.11 Newton
- ✓ Athlete n. 2: 767.96 Newton
- ✓ Athlete n. 3: 1318.35 Newton
- ✓ Athlete n. 4: 896.53 Newton
- ✓

Through this standardization, however, we didn't anything but confirming what the charts first and the numerical data then pointed out to us: athlete n.3 was the one with the highest deceleration capacity, since even in this latter analysis the average force (F) expressed by the same athlete during the close-out movement is higher than the other (a greater F corresponds to a better deceleration capacity). As for the last phase of the protocol, we analyzed the data of the athlete's change of direction between a series of 10-meter sprint. This phase for protocol included an initial sprint (10 meters), a sense change and a further twitch to return to the initial position.

Here we are able to see the similarities between this chart and the graph of the previous phase, because in both cases athletes perform a run(peaks with high intensity and high frequency); in the phase that we will analyze below, the spikes continues for several seconds and this is due to the fact that during this phase the athletes ran on a total distance of 20 meters (10 meters and 10 meters return) rather than 5 meters. For this analysis, we focused on the data obtained from the accelerometer (for the recognition of the run itself), and from the gyroscope (from which we obtained the rotation times of the players during the change of direction).

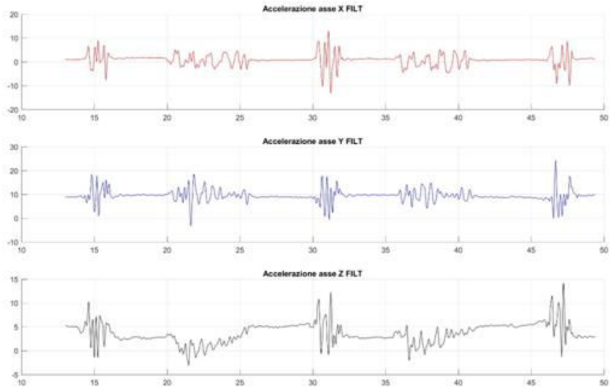

Figure 5. Acceleeration

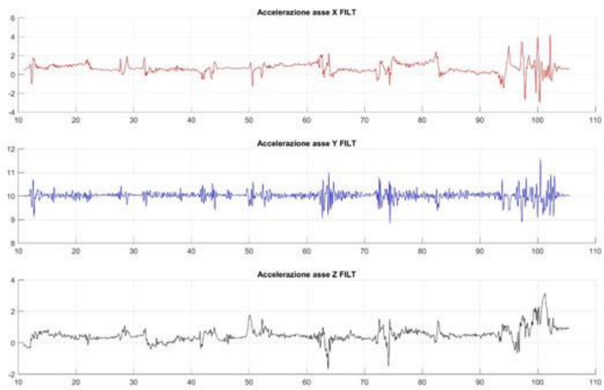

Figure 6. Acceleration

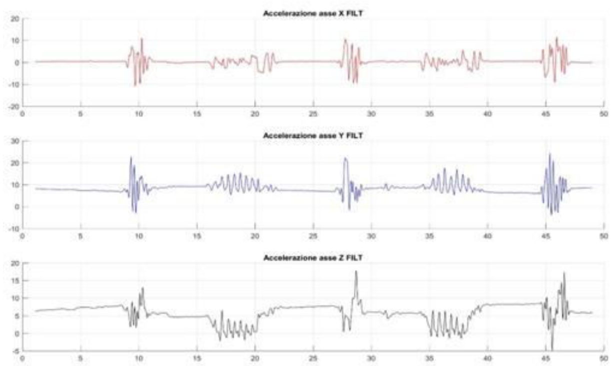

Figure 7. Acceleration

Having analyzed the run previously, we will now focus on the data obtained from the gyroscope and in particular the Y-axis data, which is the axis on which rotation occurs during the change of direction. We can see from the diagrams below as it is clear the change of direction, represented by a peak that is approximately in the middle of the typical track of the race. The interesting difference that we can see between the athlete's graph n.1 and the athlete's graph n.3 is that the rotation peaks during sense change are opposite, that is, they are all positive in the first case (also in the Athlete graphics n.2 and n.4), while they are all negative in the athlete n.3.

This difference between athlete n.3 and everyone else was explained in the next phase of analysis thanks to the use test’s footage that allowed us to properly view what was happening. In fact, athlete n.3 made a sense change with the left leg (which corresponds to a rotation towards the right), all the others made sense changes with the right leg (corresponding to a rotation toward the left). In fact, as in international convention, rotation data is considered positive for counter clockwise rotations, and negative for rotations clockwise. We can also consider a right/left imbalance if a rotation occurs on the Z axis, or a torso twist if the rotation occurs around the Y axis. If rotation occurs around the X axis, we will have a forward unbalanced body (negative values) or backward (positive values). All this is due to the orientation of the reference axes of the K-Track device. Returning to the gyroscopic data analysis, in addition to the recognition of the sense change and predisposition leg during the change, we have analyzed the rotation times of each athlete during each test provided by phase 4 of the protocol and the data we received, are shown in the following table. Minor rotation times coincide with an average speed of rotation at a higher threshold and all this can be traced back to a good direction change, allowing the player to rotate 180° in a sufficiently fast way. All these analysis will allow the evaluation of the athlete and the improvement of his features to allow him to advance not only athletically, but also from the point of view of the game, such as not losing the field view for too long during the change of direction and being ready to react in less time to new game situations (important aspect of the game studied by Altavilla & Raiola in 2014).

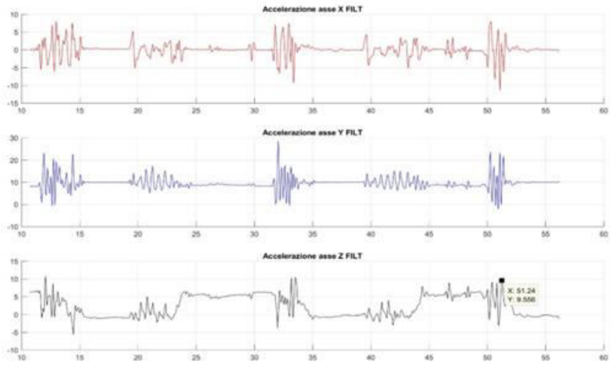

Figure 8. Acceleration

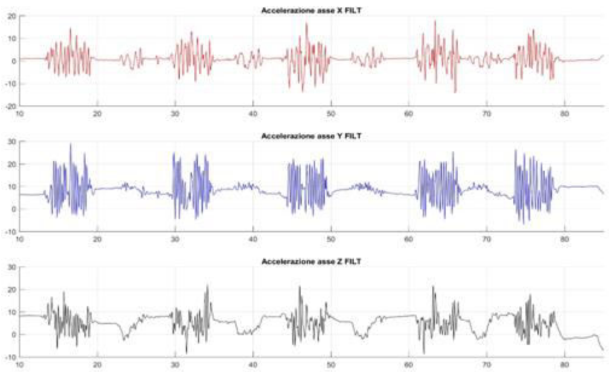

Figure 9. Last protocol's phase graph; athlete n. 3 (accelerometer) (observe how it is easily recognizable the route that represents the movement of run)

Table 4. Sit & reach and ankle dorsiflextion

	SIT & REACH TEST (cm)			ANKLE DORSIFLEXION (cm)
	TEST 1	TEST 2	TEST 3	TEST 1
Athlete n. 1	15	15	14	12
Athlete n. 2	6	8,5	7	9
Athlete n. 3	5	7	8	8
Athlete n. 4	9	10	8,5	10

Table 5. Morphology

	AGE	HEIGHT (cm)	WEIGHT (kg)	LEG PREDISPOSITION
Athlete n. 1	18	197	101	dx
Athlete n. 2	18	192	85,7	dx
Athlete n. 3	18	187	82,5	dx
Athlete n. 4	18	192	80	dx

Table 6. Rotations

	ROTATION TIMES (s)				
	Direction change n. 1	Direction change n. 2	Direction change n. 3	Direction change n. 4	Direction change n. 5
Athlete n. 1	1,11	0,68	1,06	1,31	0,8
Athlete n. 2	0,79	1,08	1,27	1,38	0,94
Athlete n. 3	0,83	0,68	0,6	0,6	0,59
Athlete n. 4	1,17	1,09	1	1,25	1,27

Discussion

When the results were displayed, the following considerations were possible:

- ✓ having analyzed the balance and stability capacity through the parameters of the variation between the threshold value and the regime value and the recovery time of the stability after performing the movements provided in phase 1 of the protocol, we can say that athlete n.4 is the most stable among the athletes considered. In fact, he has the smallest difference between threshold values and regime values and an average time (in seconds) of better stability recovery than the others, generating lower peaks of acceleration during the exercises and thus demonstrating good stability;
- ✓ from the analysis of data and graphs provided by the accelerometer of the successive step of the protocol, it was possible to recognize the movement of the running, which is represented by high intensity peaks and frequency on the axes under examination. It was also possible to identify the close-out movement, typical of the basket, which shows deceleration peaks subsequent of the typical running track. Moreover, the data provided by the accelerometer for the deceleration peaks and their subsequent standardization using the athlete's weight (m) to transform the acceleration (a) into expressed force (F), led us to consider the athlete n.3 as the best in this analysis; he is the one who has higher peaks (then stops in less time) and expresses the greatest strength during the close-out movement.
- ✓ the analysis of the last phase of the protocol has allowed us to confirm the analysis previously made for the recognition of the running movement through the accelerometer data. After that, analyzing the data provided by the gyroscope, it was possible to calculate the timing duration of the athlete’s direction change after a run on a distance of 10 m. The athlete n.3 was the most effective in the direction change, making movement in less time and at a faster speed than any other.

Conclusion

In general, this work has given us the opportunity to move the first steps towards a new and far more deep analysis of the biomechanical abilities and the physical characteristics of basketball players. The tests and the repetitions carried out and reported in this work are only a small part, a small beginning toward the development of this device and this new technology. From an analysis of young people in the youth sector, we aim to arrive to the assessment of a professional subject, at higher levels of this sport. Once you have collected and analyzed the threshold values of these subjects you will be able to draw up an assessment scale, where a certain skill or ability can be evaluated low, medium or high. However, this will be possible only after having taken into account a large number of subjects and having performed numerous examination and tests. The ultimate goal of these studies is to create a software that can identify the type of motion performed by the subject in question and define its execution level for a real-time and more in-dept analysis of this sport; a mix of science and basketball that could become of fundamental importance for the evaluation, and consequently the training, of tomorrow's players.

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ANALIZA BIOMEHANIČKIH SPOSOBNOSTI KOŠARKAŠA KROZ KORIŠTENJE 'K-STAZA' SREDSTVA

Abstract
Prepoznavanje i procjena biomehaničkih sposobnosti putem inercijskih uređaja može pružiti važne informacije o fizikalnim parametrima i funkcionalnim sposobnostima košarkaša. Ove sposobnosti, koje su donedavno ocjenjival tehničko osoblje i trener, sada se izravno procjenjuju kroz prikupljanje podataka tijekom cijelog izvođenja vježbi. U ovom radu predlažemo evaluacijsku studiju biomehaničkih sposobnosti košarkaša korištenjem inovativnog uređaja, K-staze, koja u sebi sadrži akcelerometar, žiroskop i magnetometar, te je u mogućnosti, kroz tehnologiju inercijalnog kretanja, otkriti pokrete igrača frekvencijom od 200 Hz. Također je bilo moguće prepoznati i povezati neke tipične kretnje sporta kroz određene podatke uređaja. Buduća uporaba i razvoj K-staze imaju za cilj stvaranje softvera koji može prepoznati sportašev pokret i odrediti stupanj izvršenja, što omogućuje sve dublju kvalitativnu analizu tog sporta u realnom vremenu.

Ključne riječi: *K-staza, inercijski uređaj, košarka, kvalitativna analiza.*

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Correspondence to:
Riccardo Izzo
School of Health and Sport Science, DISB,
University of Urbino Carlo Bo, Italy
Tel: +39 800 462 446
E-mail: amministrazione@uniurb.legalmail.it