The Optimization of the Running Technique using Video Analysis Method

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Abstract. Systematic and continuous monitoring of athletic performance for the purpose of developing incrementally adaptive optimized training solutions is often presented as the future of more efficient training systems. This is a shared view in the specialty literature, with authors such as Lyle J (2005, p. 21) stating that “operational training implies the existence of a continuous monitoring process, not only within a competition but also within the training and preparation”. The periodic analysis of key performance parameters with a great effect on performance during a sports contest is a process based on a coherent, self-adaptive and continuously developing system, being the result of a systemic analysis mechanism that focuses on the analytical evaluation, data collection and analytics, interpreting, and reporting the information obtained as a result of the research. Our approach is to apply and expand on the video analysis method by focusing on certain key questions: how much, how well, how precise but with what costs, with what effort, with what efficiency. Eliminating the “traditional” methods prompt the conclusions that using advanced mechatronic devices render us capable continuous monitoring, recording, and developing comparison solutions that enable concrete interventions on improving the technical execution of various athletic events and more.

Keywords: Technique, middle run, support period.

1. Introduction
The context for this paper originates with the notion of objectivization: Nicu A (1993) states that “starting from the idea that sports monitoring and preparation are two complex systems composed of a large number of components with a certain interior organization and functionality, and in order to guide them towards a well-defined purpose, we must objectify them”. Similarly, Dobre A G (2020) argues that “the particularity of monitoring sports performance contributes to the formation of the objectification system by the practical use of various video recording tools and other modern technologies”. Both approaches suggest an objective, parametrizable approach, which is becoming standard (Dingen et al., 2018) and valued as highly reliable (Maykut et al., 2015) as such tools allow for data storage, parametrization and statistical correlation that allows for insight and perspective for value judgement elaboration.

Naturally, subsidiary adaptation of the overall approach, while maintaining validity (Peebles et al., 2020) may be activity-specific: evaluating the technical preparation in middle-distance contests is directed by criteria specific to the basic mechanism of the test and Moldovan E. (2009) mentions that “the evaluation becomes important when it achieves its functions in the educational process”. Software-assisted analysis has also been a standard for decades. Epuran M (1992) highlights the importance of using the software in the evaluation process: “with more developed software individual behaviour and actions can be recorded and it can make percentage calculations on kinds of actions and behaviours, positive or
negative, technical mistakes”. Similarly, and quite remarkably, two-dimensional video analysis on the 1500 meter can be easily carried out and allows for the sequential reproduction of mistakes. Potential errors and mistakes in the execution technique may be incremented starting from those with the highest significance, in a case-specific stratification of remediable errors, and tracing will be carried out with modern technologies for the purpose of elaborating a personalized, practical, plan of diverse remedial exercises catering for individual necessities on a case-by-case basis. At this point, it is of utmost importance that the assessment of the technicality index of the execution and the comparison of the results to be permanently related to the existing models in the specialized literature.

Dobre A G (2020) supports that “this comparison of the parameters obtained using video analysis has more advantages because it can see the perception of its own warts and all, and it can find individual technical guidance by identifying new options for improving the technique of the runners”. Indeed, we can appreciate that the video analysis done with a sense of responsibility can massively contribute to creating the technical model and thus, it offers the athlete the possibility to compare their subjective perception of their own performance with an objective, irrefutable and reproduceable reality.

Training for mastering any technique involves patience, developing new skills is always a slow process and always requires attention and dedication from the athlete as well as from the trainer. Using advanced technologies especially when training juniors, for example, would mean that performance results may be used as feedback than informs future training sessions and incremental improves the overall efficiency of training. The consequences for such an approach are obvious, Prescorciță A and Tohaneanu D (2008) consider that “the last training stage highlights the high-performance preparation, with an emphasis on achieving maximum performance due to the assimilation in the technical tests of optimal motor skills”.

The technical preparation represents an important component of sports training and emphasizes the scientific method and a data-driven approach. During the technical preparation, it will be taken into consideration that “the exercises’ technique in athletics should not be appreciated only from a kinetic point of view (the sequence of apparent movements), but from the forces that interfere when executed, forces that are not visible outside, so after their dynamics” (Țifrea C, 2002). This notion is not dissimilar to what other authors posit, Gagea A (2006) argues that “if we talk about the sports’ biomechanics then the efficiency is related to the technical execution of some movements, and by improving the technique, we improve sports performance”. On this note, our current approach explores this line of thinking and investigates an advanced monitoring system capable of continuous tracking and improving based on objective-data analytics.

2. Materials and Methods

After establishing the theoretical aspects specific to the evaluation and monitoring of the technical aspects in the middle-distance running, our main objective was to perform an analysis of the running technique based on the video recordings processed via a modern software solution in order to make it possible to trace the slightest mistakes and errors of body segment movements during the 1500 meter run. To reiterate, the theoretical framework precedes technical aspects which are built on video analysis of movement. Tracing body segment movements throughout the 1500 meter run is parametrizable, and we will continue to discuss this parametrization.

2.1. Kinematic Parameters of the Middle-distance Running Step Subjected to Analysis – Case Study

Real needs of training stages and competitions require a mix of motoric skills, which are analyzed using energetic and control parameters (Mereuta C, Ganea D, Mereuta E, 2013). For the technical analysis of the running, we have taken into consideration two types of running steps: simple and double. At the same time, we have considered the two periods of the running step, namely: the stance and the swing. We have studied the stance period formed of three distinct phases that condition each other (absorption, vertical moment, and propulsion) for which we have established the following kinematic parameters: duration of the absorption phase, horizontal speed of the hip, knee, and ankle joint during the absorption phase, horizontal speed of the hip joint in the vertical moment, active duration of the propulsion, and propulsion angle.
After establishing the kinematic parameters subjected to observation in the educational process, we have identified the best analysis methods and means of the most important moments of middle-distance running with which to improve, correct, or adjust the technical performances of junior athletes.

2.2. Video Recording and Analysis Techniques Used in Research

Mereuta E and Mereuta C (2012) argue that “the researches in pedagogy face complex phenomena which randomly modify under the influence of random factors”.

The research implies the use of a high-performance camera which ensures an objective measurement. Because this study was based on video analysis with the purpose of obtaining some data of major interest connected to the middle-distance running step technique, we have decided that the video recordings would be carried out with a high-performance camera and processed with the Kinovea software. Kinovea is a video analysis software that allows capturing and replaying, at different speeds, video recordings with the possibility of analysing kinematic parameters. It was specially created for analysing movements from various sports in order to improve sport performance (Guzman-Valvidia C. H., 2013; Elwardany S. H., 2015).

2.3. Subjects, Locations, and Periodization of Research

For the competition year 2017-2018, we started a pedagogical experiment with regards to the optimization method of the running technique of the middle-distance running step.

We conducted a case study on an athlete, junior I, specialised in the 1500 meter run (table 1, table 2), competing in national competitions for juniors and youth. The first test was done on October 2017 at “Dunarea” Stadium from Galati in collaboration with the Research Center of Human Performance within “Dunarea de Jos” University of Galati. Mereuta C (2018) supports that “the higher education institutions of Physical Education and Sports have a teaching and scientific research mission, by ensuring the transfer of specialized information, stimulating and supporting the creation and sport performance in the field of physical education, sport and human motricity”, which we assess as support and encouragement for such pedagogical experiments taking place. Moreover, informed consent on behalf of participants and explanations with regards to how this method may improve their results and overall performance was met with a significant level of enthusiasm.

The first test consisted of an entire video recording of the 1500 meter race with a high-performance camera and a “Phantom 3 Professional” drone. The second test was carried out similarly to the first, however, it was carried out on April 2018. Both tests were processed with the Kinovea analysis software, taking into account that the modern investigation technologies of the human motricity kinematics can reveal major interest data which highlights certain relevant indicators for the running technique for the 1500 meter run. After the data, generated by the software, was processed, the athlete started an individualized technical training program according to the settled deficiencies.

The training by non-specific means involved an assortment of: jumping on steps, sprints on steps, leaping steps on steps, jumping steps on steps, jumps on tiptoes with elastic rope, free and from the squat position, jumping over obstacles on the spot and on the move; combinations of jumps on the sport and on the move, exercises with dumbbells, medicinal balls, elastic bands, squats with vertical detachment and extension.

The following are specific training methods: various types of walking, flying run (in a straight line and in a turn), uphill flying run (in a straight line and in a turn), flying run with acceleration for the last 20 m (in a straight line and in a turn), front and backwards running in the direction of the treadmill and of the track, running with a different contact (ball of the foot, entire sole, heel), running on the treadmill, running on the treadmill inclined, side running on the treadmill etc.

| Crt. no. | Experiment participant | Year of birth | Title obtained at national level | Personal best in the 1500 m race (min.) |
|---------|------------------------|---------------|---------------------------------|----------------------------------------|
| 1       | Subject 1              | 2000          | National vice-champion           | 4’38’’                                  |
3. Results and Debates

3.1. Case Study - Analysis of the Absorption Duration and the Variation of the Horizontal Speed in this Stage

### Table 2. The athlete’s anthropometric data.

| Crt no. | Experiment participant | Height (cm.) | Weight (kg.) | Breadth (cm.) | Sole length (cm.) | H. bust (cm.) | P. abd. (cm.) |
|---------|------------------------|--------------|--------------|---------------|------------------|---------------|---------------|
| 1       | Subject 1              | 164          | 51           | 160           | 23               | 90            | 68            |

### Table 3. Duration of the absorption phase in T1 (initial test) and T2 (final test).

| Crt no. | Experiment participant | Duration of the absorption phase (ms) in initial test | Duration of the absorption phase (ms) in final test | Difference (ms) |
|---------|------------------------|-------------------------------------------------------|---------------------------------------------------|-----------------|
| 1       | Subject 1              | 133                                                   | 117                                               | 16              |

### Table 4. The values of the horizontal speed of the joints in the absorption phase for S1 in T1 (initial test) and T2 (final test)

| Test     | Subject 1 | V.X. (m/s) hip joint | V.X. (m/s) knee joint | V.X. (m/s) ankle joint |
|----------|-----------|----------------------|-----------------------|-----------------------|
| Initial test | S1       | 0.45-0.47           | 0.39-0.42             | 0.23-0.15             |
| Final test    | S1       | 0.63-0.59           | 0.51-0.39             | 0.30-0.21             |
| Dif.                  | S1       | 0.18-0.12           | 0.12-0.03             | 0.07-0.06             |

The horizontal speed has a static consolidation regime in which the muscles develop force without movement, namely consolidation force. From a mechanical point of view, there is no movement, but anatomically there is at the joint level by the synovial fluid and cartilages. In this phase, the absorption (table 3), there is contact with the ground. The ground’s reaction has a negative influence on the running speed, slowing the continuity of running. At the moment of the impact with the ground, the inferior segment bends and absorbs the shock and the horizontal speed is reduced (figure 1a and figure 1b). The joints that do the absorption are the knee and hip joints. The ankle joint does not participate in this phase. The chart will be interpreted, starting from the conclusion of the specialists that in case of a correct running technique, in this stage, the horizontal speed of the hip and knee must decrease, and not the ankle’s speed, remaining constant.
Table 5. The absorption phase duration in T1 (initial test) and T2 (final test)

|         | T1       | T2       |
|---------|----------|----------|
| Duration of the absorption phase in T1 and T2 | 105 ms, | 117 ms, |
|         | 110 ms,  | 117 ms,  |
|         | 115 ms,  | 117 ms,  |
|         | 120 ms,  | 117 ms,  |
|         | 125 ms,  | 117 ms,  |
|         | 130 ms,  |          |
|         | 135 ms,  |          |

Table 6. Horizontal speed variation during the absorption phase in T1 (initial test) and T2 (final test).

After implementing the preparation program, in the analysis of the recording in final test we had observed that for Subject 1 (table 6) the horizontal speed of the hip and knee joint decreases, but at higher indices than the initial test. The speed of the hip joint decreases between 0,64 and 0,59 m/s compared to 0,45-0,47 m/s from the initial testing where the values were lower than 0,18-0,12 m/s. The horizontal speed of the knee joint has the same descending trajectory, decreasing between 0,51-0,39 m/s than 0,39-0,42 m/s (we get here a difference of 0,12-0,03 m/s).
Regarding the ankle joint, it can be seen a decrease of the horizontal speed during the absorption, the same as in initial test, although it is advisable to be steady. This happens between values of 0,11-0,08 m/s, bigger (0,30-0,21 m/s) than those from the initial test (0,23-0,15 m/s). There are improvements regarding the horizontal speed trajectory of the hip and knee joints.

3.2. Case Study – Comparative Analysis of the Horizontal Speed Variation of the Hip in the Vertical Moment in T1 (initial test) and T2 (final test)

Table 7. The horizontal speed of the hip joint in the vertical moment in T1 (initial test) and T2 (final test)

| Vertical moment (ms) | V.X. hip joint (m/s) |
|----------------------|----------------------|
| Initial test         | 1100                 | 0,39             |
| Final test           | 1110                 | 0,35             |
| Dif.                 | -                    | 0,04             |

Table 8. The horizontal speed variation in the vertical moment in T1 (initial test) and T2 (final test)

In the case of Subject 1 (table 8), the horizontal speed of the hip joint in the vertical moment is the lowest in both tests (0,59 m/s at initial test and 0,35 at final test), however, the differences regarding the same speed in the improvement phase (0,45 m/s at initial test and 0,39 at final test) are insignificant. There are slight improvements, however, further action is needed to correct the technical deficiencies settled during the support period of the middle-distance runner.

3.3. Case Study - Comparative Analysis of the Propulsion Phase Duration and Propulsion Angle in T1 (initial test) and T2 (final test)

Table 9. The propulsion phase duration and the propulsion angle in T1 (initial test) and T2 (final test)

| Propulsion phase duration (ms) | Propulsion angle (°) |
|--------------------------------|----------------------|
| Initial test                   | 1100                 | 62,08             |
| Final test                     | 1050                 | 58,18             |
| Dif.                           | 50                   | 3,9               |
Table 10. The active duration of the propulsion phase in T1 (initial test) and T2 (final test)

In table 10, the evolution of the propulsion phase duration is displayed for Subject 1, where it can be observed that it has decreased with 50 ms than the time registered in initial test, which indicates an individual progress, our objective being that of making the propulsion faster and more efficient.

4. Conclusions
We have found out that at the national level, the methods and techniques for evaluating the biomechanics are not used in the sports training of athletes. The monitoring of kinematic parameters of the middle-distance running step is not carried out in the technical preparation at no level of organization of this sport.

The evaluation and monitoring of the entire preparation process must be done with sense of responsibility because there are complex processes which involve the usage of state-of-the-art technology by which it is possible to reach the objectification of the motor structures, the correction of the individual mistakes in order to increase the efficiency and to improve the sports results. It ensures the scientific guidance of the athletes by offering real and permanent feedback.

The video recording and analysis method can be a successful observational tool when it is applied constantly in the preparation process of the athletes. At the same time, it is a valuable tool for awareness and correcting the settled technical mistakes or deficiencies.

The settled technical deficiencies in junior athletes were more than highlighted after they were monitored during the research, and it brought up to light some aspects described below.
About the technical aspects, the contact with the ground indicates automatism and highlights a lot of execution mistakes since the beginning of the absorption. The ground contact duration could be improved by decreasing the total absorption and propulsion time.

The horizontal speed of the hip and knee joints, in the absorption phase of the athlete who participates in the experiment, increases, instead of having a downward course due to the fact that at this stage the contact with the ground takes place, and its reaction has a negative influence on the movement speed, slowing the continuity of running.

At the moment of impact with the ground, the inferior segment flexes to absorb the shock and the horizontal speed automatically decreases. In terms of horizontal speeds for the three joints, considerable improvements could be brought.

The training program implemented (which is a personal contribution) after the processing of the video recordings in Kinovea showed its efficiency, proving that by video analysis, carried out rigorously with high-performance software, we can obtain particularly important data in improving the execution of the running techniques which could lead to a higher capacity and better performances in competitions.

The personal contribution in this paper is given by the fact that I wanted to implement video analysis in endurance running in athletics in order to obtain concrete data about the possible causes underlying technical errors.

Based on the stored data, we have developed a list of technical mistakes (table 11 and table 12) for Subject 1, mentioning also the causes that stood at their setting, in order to find the most effective means of correction related to the particularities of the analyzed subject.

**Table 11. Individual technical mistakes traced after the video analysis – Subject 1**

| Kinematic parameter | Subject 1 – technical mistakes |
|---------------------|--------------------------------|
| **Absorption phase** |                                 |
| Start of the absorption (contact with the ground) | The contact with the ground is poor, performed on the heels. |
| Total duration of the phase | Total time = 133 ms, a relatively long duration. |
| Horizontal speeds of the studied joints (hip, knee, ankle) | They have chaotic modifications, behaving oppositely than it is recommended, and that is the hip and knee joint speed increases instead of having a downward course, and the ankle speed (which should be constant in this period) decreases. |
| **Propulsion phase** |                                 |
| Active phase of the propulsion | Large, total = 1033 ms. |
| Propulsion angle | It has a value of 62,08° and the cause is the slow movement of the inferior limb due to the lack of the necessary force for the quick and efficient detachment of the foot from the ground. |

**Table 12. Detected causes of individual technical mistakes – Subject 1**

| Case study | Technical mistakes | Causes of the mistakes |
|------------|--------------------|------------------------|
| **Subject 1** | The contact with the ground is poor, performed on the heels. | Lack of a proper technique to improve the shock with the ground contact at the beginning of the absorption phase. |
| **Subject 1** | The total duration of the absorption phase is long. | Incomplete rolling of the sole on the ground, insufficiently developed force in the lower limbs. |
Subject 1 The horizontal speeds of the studied joints change chaotically, behaving oppositely to what is recommended. The lack of proper technique when making contact with the ground causes a chaotic change in these horizontal speeds. The lower limbs are not consciously controlled in the running step.

Subject 1 The active phase of the propulsion takes place over a long period of time. The idle work of the segments involved in the movement.

Insufficiently developed force.

Subject 1 The propulsion angle has high values. Insufficiently developed force at the level of the lower limbs.

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