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THE ROLE OF GPS TECHNOLOGIES IN THE PREPARATION OF JUNIORS FOR THE SPORTS ORIENTEERING

Andrei GOLOVEI [1]

Abstract: *Currently, information technologies play a crucial role in the planning and organization of orienteering events, facilitating both the competition process and the training of athletes. The theoretical study of the issue highlights that with the development of GPS systems, which represent the subject of this research, it has become possible to record juniors' performances during training. This allows the coach to adjust the junior athlete's technique and helps the athlete correct mistakes. The study results indicate that the special function of GPS to record race routes plays a significant role in the analysis of orienteering training, thus the application of these techniques can enhance learning efficiency in the training process.*

Key words: *GPS, orienteering, juniors, technique.*

1. Introduction

Orienteering is a complex sport in which technical training plays a crucial role in achieving performance. However, the specific technical and tactical characteristics and the requirements for integrating various techniques are not fully studied, which may influence athletes' success in competitions. Even top athletes make technical and tactical errors in major competitions, including the World Championships. In the case of junior athletes, deficiencies in technical training can significantly slow progress, despite the effort invested in training. In this context, the use of modern technologies, especially GPS-based systems, opens new opportunities for analyzing and improving the technical preparation of juniors in orienteering. With the advent of these technologies, new solutions have emerged to address one of the fundamental challenges in orienteering, which is the establishment of direct contact between the athlete executing technical actions in the field and the coach [1].

In recent years, science and technology have not only gradually changed people's lives and the world but have also influenced how we engage in various sports activities. Under the influence of this changing trend, orienteering, a sport with a history of over 100 years, has integrated remarkable technical

[1] Institute of Physical Education and Sport, Chisinau, Republic of Moldova.

components such as electronic timing systems and Global Positioning System (GPS) technology. These are widely used in project development, cartography, training, and sports broadcasting, contributing to technological progress [6, 10]. Thus, investigating and implementing GPS technologies in the technical training of junior athletes has become a relevant topic for optimizing the training process and advancing the sport of orienteering.

Given the complexity of navigating varied terrains, junior orienteers often face challenges in map interpretation, making quick route decisions, and maintaining orientation under physical exertion. These challenges highlight the need for targeted training strategies based on concrete data that go beyond traditional preparation methods. By integrating GPS systems into training, coaches can gain an objective view of each athlete's decisions and performance, even in real forest conditions. This allows for more accurate feedback, personalized corrections, and much more efficient strategic planning. Moreover, for junior athletes who are in a crucial stage of developing spatial thinking and the ability to make decisions under pressure, GPS-based analysis becomes both an educational and motivational tool, fostering autonomy, reflection, and progress tracking.

2. Materials and Methods

The aim of the research is to identify the contribution of GPS technologies to the training of junior athletes in orienteering.

2.1. Research objectives:

1. Theoretical and methodological analysis of the role of GPS technologies in the training of junior athletes in orienteering.
2. Identification of key aspects of using GPS systems in the training of junior athletes practicing orienteering.
3. The role of GPS systems in the training methodology for orienteering.

2.2. Research methods

The methods that enabled this research focused on the theoretical and scientific foundation of the studied problem, pedagogical observation, and field study.

3. Results and Discussions

Currently, in orienteering, the use of information technologies has evolved significantly, and today there is a wide range of specialized tools for various aspects of competition organization and training processes. The latter represents a crucial process through which junior athletes achieve sports performance, but it must always be organized and conducted using a series of methods and tools that enhance athletes' results. In this regard, an essential tool in the training process can be the Global Positioning System (GPS).

The Global Positioning System consists of satellites, ground control centers, and receivers. With the help of this system, it is possible to determine the exact location of a subject on Earth and facilitate navigation in a three-dimensional space (latitude, longitude, and altitude) [9].

Orienteering is not just a cross-country race, it also involves a significant number of cognitive factors, which become necessary and very important in the training process of junior athletes. In the

training process, the problem athletes need to consider is route selection. Athletes can choose different routes even if they are at the same location, which makes the analysis of the training process quite complex. Prior to this, many studies were conducted in the field of orienteering from the perspectives of physiology and sports psychology [7], but these studies were not carried out in the context of orienteering training.

A special function of GPS, the ability to record the course route, plays an important role in analysing the training process of junior athletes in orienteering. By applying the route recording function and analysing the data through specialized software, a concrete analysis of the actual route traversal process can be obtained. All of this helps identify the weaknesses and advantages of the junior athlete, leading to a rational planning of the training process.

Currently, the main GPS receivers are capable of collecting data and monitoring heart rate, with a focus on the special features of orienteering. They reflect the athlete's route during the training process. Throughout the route during the training with juniors, GPS systems can continuously generate relevant information, such as: the distance from the start line, instantaneous speed, and the total accumulated elevation gain (Figure 1).

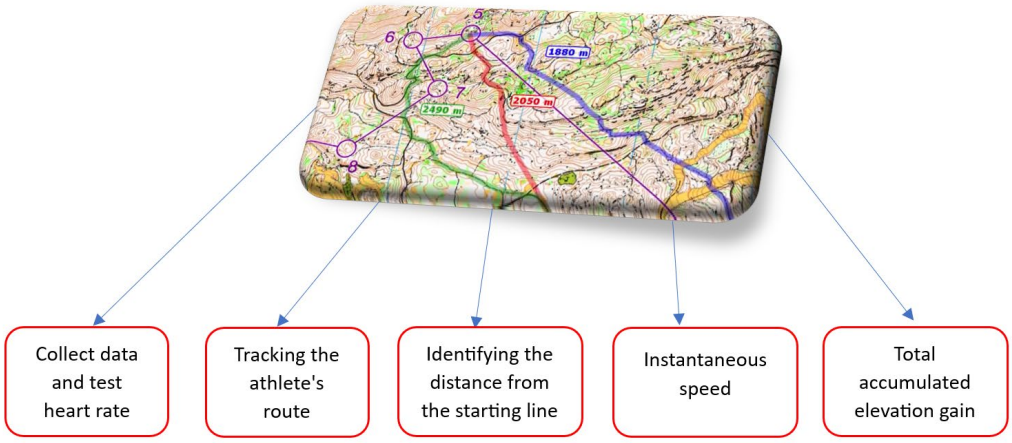

Fig. 1. *Role of the GPS system in the training process of junior athletes in orienteering*

The essence of GPS tracking technology is the sequential recording of a movement route and then plotting it on a map, diagram, photograph, or aerial photograph from space. The next step in training management is a detailed analysis of the collected data, both with and without the athlete. All of this allows the coach to adjust the training plan based on conclusive data. Additionally, it is very important for the coach to have the ability to monitor the athlete's actions in real time on a computer, considering that due to the large length of the trail in the forest, it is quite difficult to monitor the athlete on every chosen route to reach control points, due to the terrain's relief. Therefore, GPS trackers can facilitate the tracking of participants' movements, collect statistics, and control the start time

and deviations from the trail [12]. GPS trackers (e.g., Sportrec trackers), which transmit real-time data about the athlete's position on the field, are attached to the athletes' backs and have a SIM card. This method is quite complex and is used more in orienteering competition events than in training. During training, tracking athletes can be done using GPS-enabled watches and/or smartphones. In both cases, the accuracy of the GPS is important, as the training route may include complex terrain features (Figure 2).

Fig. 2. *GPS devices used in orienteering in competition and training processes*

GPS devices used in the training process of junior athletes, such as watches, will not transmit real-time data but will store the athlete's positioning on the terrain every second. At the end of the training, the data from the watch will be transmitted to software (e.g., Livelox) that will overlay the track onto the real map, which must be georeferenced. The application allows for the visualization of the entire route completed by an athlete (Figure 3) and/or the visualization of a specific section completed by all athletes who have uploaded their data to the application.

Fig. 3. *Track of full race with GPS coordinates on a georeferenced map in orienteering*

Livelox not only allows the overlay of the athlete's route on the actual competition or training map but also enables comparative analysis between multiple athletes who participated in the same course. Through the real-time route playback feature, coaches and athletes can simultaneously follow the movements of all participants, observing differences in route choices, running speed, stops, hesitations, or navigation mistakes. This feature is particularly valuable for understanding how in-field decisions impact the final result, as well as for developing junior athletes' tactical analysis skills (Figure 4).

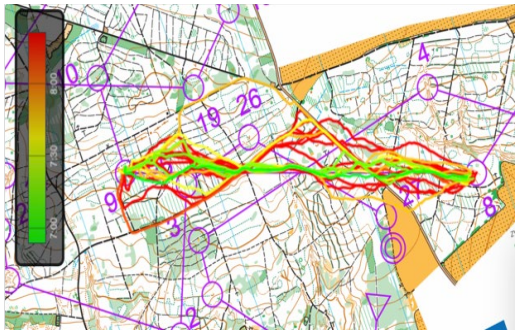

Fig. 4. *Track of one segment with GPS coordinates on a georeferenced map in orienteering*

With the help of the software, an individual analysis of the crossing technique of the route and a comparative analysis with other athletes can be carried out.

The proposed methodology for analysing the athlete's actions during the training process can rely on several methods, which can be used to analyse the distances covered by the athlete, creating a clear and complete picture of everything that happened to the athlete in the forest. For this, there are several methods that can be effective in the athlete's training process: the method of comparing distances; the method of comparing route profiles; the method of comparing "split-time" of route segments; the method of comparing "split-time" of route segments, considering speed data; the method of comparing "split-time" of route segments, taking into account heart rate data (Figure 5) [4].

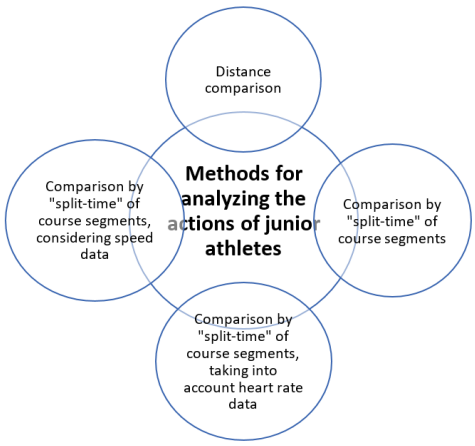

Fig. 5. *Methods for analysing junior athletes' actions on the course as a result of using GPS systems*

The accuracy of the analysis increases significantly when the data from Livelox is complemented with information obtained by punching control stations using electronic chips. To compare split times, electronic control stations are placed in the field, which record the exact moment the athlete reaches each control point. The athlete wears an electronic chip that stores the timestamp of each punch (Figure 6).

Fig. 6. *Control station*

At the end of the course, the athlete "downloads" the data from the chip to a computer, which records the time of punching at each control point. The computer then calculates the time taken for each leg of the course (Figure 7). By comparing the junior athlete's split times with the data recorded by the GPS tracker, the accuracy of how each leg was executed can be analysed.

An analysis of a training session highlighted that GPS usage must be correlated with split-time analysis in order to effectively monitor the training process of junior athletes.

Rez.	1 - 38	2 - 34	3 - 35
0:19.45	2.06 (2)	2.10 (1)	0.50 (4)
	2.06 (2)	4.16 (1)	5.06 (1)
0:22.04	2.19 (5)	2.46 (2)	0.51 (5)
	2.19 (5)	5.05 (2)	5.56 (3)
0:23.40	2.03 (1)	6.03 (12)	0.37 (1)
	2.03 (1)	8.06 (8)	8.43 (7)
0:24.24	2.19 (5)	3.25 (4)	1.00 (11)
	2.19 (5)	5.44 (4)	6.44 (4)
0:24.50	2.20 (7)	2.46 (2)	0.45 (3)
	2.20 (7)	5.06 (3)	5.51 (2)

Fig. 7. *Split-time of junior athletes in the training process*

For the effectiveness of applying the GPS system in the training process, a key role in preparing junior athletes for orienteering lies in the communication channel, which includes the location data received by the GPS device through communication and transmitted to the monitoring centre in various ways [8].

Studies conducted by Sirakov, I., and Belomazheva-Dimitrova, S. (2018) highlight the fact that most athletes practicing orienteering are adamant about the importance of applying the GPS system in the training process, as the athlete's development is achieved through tracking their actions in a real activity and space environment [11].

The data collected using GPS trackers or watches can provide a detailed picture of a junior athlete's behaviour on the course, allowing for the identification and correction of mistakes that would be difficult to detect if relying only on the athlete's impressions. Among the most encountered mistakes among junior athletes are [2, 3]:

1. **Wrong route choice:** the athlete may choose a route option that, although it seems safer or clearer, is significantly longer or more physically demanding. GPS analysis allows for an objective comparison of route options between different athletes, providing immediate feedback on the efficiency of the choice made.
2. **Unjustified stops or hesitations:** the GPS route can show points where the athlete stopped or significantly slowed down without an obvious reason in the field (e.g., difficulty reading the map, lack of confidence in the decision). These moments may indicate uncertainty or a lack of a clear plan for attacking the control point.
3. **Deviations from the correct direction**: especially in terrains with reduced visibility and/or flat terrain, athletes may deviate from the ideal direction. The GPS route highlights these deviations, particularly when the route line forms a curve or angle compared to the straight line between control points.
4. **Detours or avoidance of obstacles without reason:** sometimes, athletes avoid obstacles (vegetation, terrain, marshes, etc.) that could be easily crossed. This behaviour may indicate a lack of experience or overestimating the difficulty of the terrain. The GPS highlights these moments and allows for a discussion about the risk-benefit ratio.
5. **Premature attack on the control point:** some athletes enter the "attack zone" of the control point too early, losing time through unnecessary searches. Through analysis, it is possible to identify the moments when the athlete began searching without a clear attack point or without using nearby orienting features.
6. **Lack of a straight line between control points**: in the absence of confidence or a precise bearing, junior athletes may run in "wavy" lines between control points, increasing the total distance covered. This behaviour is common and can be corrected through specific direction-maintenance training.

The use of GPS in orienteering training for juniors has a significant impact on their psychological and motivational development. It not only provides valuable technical data but also influences how they understand their performance and the progress they have made.

One of the key aspects of this impact is the ability to better understand one's own mistakes. GPS allows for a detailed analysis of the route taken by an athlete, including the time required for each segment and any deviations from the correct path. This type of feedback helps coaches identify errors and find ways to correct them in future training sessions. Instead of relying solely on personal impressions or the coach's observations, athletes can clearly visualize the moments they went wrong and learn from those mistakes.

In addition, GPS provides juniors with a valuable opportunity to visualize long-term progress. By comparing data from various training sessions, they can observe improvements—whether it's faster speed, quicker route choices, or more efficient approaches to control points. This ongoing monitoring process helps them become aware of their development, which boosts their motivation to continue training and improve their performance. When juniors can consistently see their progress, they feel more motivated to overcome obstacles and achieve their goals.

Another important aspect of using GPS is the active involvement of athletes in analysing their own performance. It is no longer just a tool for coaches but becomes a partner for the athlete in the process of self-development. Juniors can study the GPS data, discuss it with their coaches, and work together to identify the weak points in their training. This collaborative process not only improves their performance but also strengthens the coach-athlete relationship.

Visible improvements in performance contribute to the growth of juniors' self-confidence. When they see how their previous mistakes are corrected and how their technique becomes more precise, they begin to experience a sense of success and satisfaction. This increase in confidence in their own abilities motivates them to participate more enthusiastically in training and competitions. This positive cycle of self-appreciation ultimately supports the achievement of better athletic performance.

In the long term, the use of GPS contributes to the strengthening of athletes' intrinsic motivation. Observations made throughout the training process have highlighted that juniors who are able to analyse their own progress become more self-aware and responsible in their training. As a result, they develop clear objectives and a sustained desire to continue training and competing, not just for the purpose of winning, but to improve and become better each day.

In conclusion, GPS is a tool used in the training process that needs to be combined with other informational technologies employed in the preparation of juniors for orienteering events.

4. Conclusions

Currently, modern technologies are becoming increasingly prominent in the orienteering discipline. With the development of GPS systems, orienteering competitions have become much more attractive, and their potential can also influence the training process. These technologies allow for a detailed evaluation of junior athletes' activities during training, providing information about the routes taken, decisions made on the field, and the efficiency of techniques used by the athlete. All of this is beneficial to the coach, who, in the training process,

can analyse in real-time by monitoring the GPS system on a computer or another available accessory to assess the athlete's technique.

The use of GPS systems and analysis applications, such as Livelox, not only optimizes the training process but also provides a valuable opportunity for the development of critical thinking in junior athletes. They can learn to reflect on their own decisions, identify mistakes made, and improve their orienteering strategies in the field. Furthermore, technology contributes to increasing motivation by ensuring athletes' progress.

Thus, the integration of technology into orienteering training is not just a modern trend but a necessity in the development of performance, especially at the junior level. The future of the sport lies in a smart blend of tradition and innovation, and coaches who adopt these tools in orienteering will ensure the efficient preparation of athletes, meaning that training processes will become much more dynamic and effective.

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