Assessment of Visuomotor Coordination in Team Sports: Concept and Implementation

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Abstract: Coordination skills are among the main components of success in team sports. Despite the wide development and distribution of methods for coordination development in sport, there is a lack of objective monitoring methods for coordination assessment especially in the context of changes in the terms of game situation. The article presents a unique innovative method for objective coordination assessment based on the team sport training system "Co-Star". Co-Star includes fixed position of sensors and proprietary activation algorithms. Thus an objective and reliable evaluation of the bond «stimulus - reaction - precise action» is-carried out. This evaluation method allows to estimate both athlete's own (general) visuomotor coordination as well as specific coordination with the use of game equipment (ball or racket). Co-Star system may be useful in training and testing athletes of all ages from young ones to professionals in team sports. The proposed athletes age norms formed as a result of our research potentially would-help in sports selection.

1 INTRODUCTION

The significance of coordination development has been the subject of extensive research in the field of sports science (Issurin, Lyakh, 2017). Coordination is particularly crucial in competitive sports, where it encompasses a multitude of elements, including the ability to swiftly assess the situation, react with precision, make conscious decisions and fulfil motor actions efficiently. Above mentioned elements together contribute to achieving successful outcomes in team sport, which may take the form of scoring a goal, dribbling under pressure, skillfully taking a ball from opposing teams, or accurately passing it to a teammate. All the components of a sporting performance are accomplished through a carefully coordinated sequence of "*stimulus - reaction - precise action*". The success of an athlete much depends on the effectiveness of this sequence (Breaker, 2011, Lienhard 2019, 2021, Smith, 2021).

Despite the wide variety of potential methods available for developing coordination skills through the use of various simulators and supplementary tools, a significant gap remains in the availability of methods for reliable assessment of situational coordination. This issue requires the development of new methods.

The development of digital technologies allows us to use them as sports monitoring instruments and simulators for response speed training. Modern Light sport training systems sensors (Levy et al., 2021) operate on the principle of "*stimulus 1-response-stimulus 2…*" that enables to create unexpected stimuli and measure response times, which can be used as a basis for developing new methods of assessment.

The concept of our investigation was: using sport light training system permits to assess the spatial visuomotor coordination which has crucial importance in team sports.

2 METHODS

The presentation of the methodology for visuomotor coordination assessment was divided into three key

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components: method design (a description of the apparatus with software and a process of their development), testing procedure and data analysis.

2.1 Method Design

The aim was to develop a spatial visuomotor coordination testing system for assessment of the performance speed of a coordinated precise action in response to a change in the situation around the athlete.

It required selection of sensors with their software, sensor positioning and technical solutions aimed both at ensuring their stability, as well as adaptability, mobility, and versatility of the testing system.

1) It would be most advantageous to use existing reflex simulators as a starting point.

2) The sensors need to be fine-tuned to capture the data as accurately as possible.

3) The software must guarantee objectivity and precision in recording the "*stimulus - reaction - precise action*" time.

4) Sensors must be fixed around the athlete.

5) To activate both legs and arms the sensors should be above the floor, better on racks.

6) The number of stimuli must be sufficient to alter the situation around the athlete, without overwhelming them by excessive sensors.

7) At least one sensor should be positioned outside the athlete's field of vision.

8) The racks on which the sensors are mounted must be secured with clamp, forming a closed loop.

9) The contour side of the system should be designed to optimally accommodate the anthropometric characteristics of the athlete.

10) The system should allow the conduct of tests involving game equipment (balls), providing a comprehensive evaluation of the athlete's performance.

11) The system must be collapsible and compact, facilitating transportation and field testing in various environments.

What has been achieved?

In the development of the Co-Star system we have opted for X-light, light-based sports sensors. The sensor contains LEDs and a photodiode. This choice was based on a thorough analysis of existing lighting simulation devices available in the market (Ezhov et al., 2021).

These sensors are easily disassembled, allowing fine tuning to improve the accuracy of data recording: increasing the sensitivity of touch sensors and changing the operating mode of the photosensor. Thus, we obtained sensors with deactivation distances in the range 1-3 centimeters.

The sensors are of a hexagonal shape with a side length of 70 millimeters and each weight is only 0.15 kilograms (Figure 1). These sensors are easily integrated into universal camera mounts.

Figure 1: Co-star sensor.

Moreover, the standard X-Light software has been enhanced with changes of settings for light stimulation, remote and tactile deactivation and time fixation algorithms.

To reduce the impact of diverse anthropometric features of athletes and ensure a closed circuit with an adequate number of sensors, including one positioned outside the visual field, we conducted an experiment selection of the shape of a regular pentagon (Figure 2). The side length of 1 500 millimeters has proven to be optimal for individuals with varying ages and anthropometric dimensions.

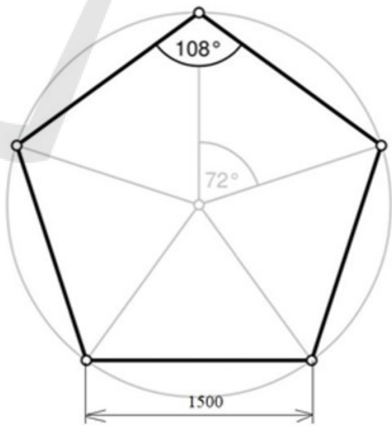

Figure 2: Co-star scheme.

Sensors were fixed on a tripod equipped with a standard 3/4-inch photographic bracket allowing for height adjustment in the range of 500-1200 millimeters (Figure 3).

Figure 3: Co-star tripod + photo mount.

Figure 4: Co-star jumpers.

Figure 5: Co-star.

The tripods were firmly secured together using collapsible rods 1,480 millimeters in length with a detachable clip (Figure 4) to form a regular pentagonal configuration (Figure 5). Thanks to the pentagon shape of the sensor positioning the system received its name Co-Star.

To facilitate transportation necessary for field testing Co-Star system has been designed in a modular format that can be packed into Co-Star backpack (Figure 6).

Figure 6: Co-star packaging

2.2 Co-Star Testing Method

The test is performed after a pre-test warm-up. The athlete steps inside the perimeter of Co-Star and takes any position. The athlete is instructed to deactivate the light sensors as quickly as possible. Light sensors activate randomly after the "READY? GO!” command. Sensor activation delay (the time between deactivation of the sensor and activation the next one) is about 0.1 s. The test duration is 30 seconds. The test result is calculated by the Co-Star software as average sensor deactivation time with precision 0.01 s. Subject of the test is making two separate trials. Best result of both attempts is recorded.

Figure 7: Co-Star standard test.

2.3 Description of the Participants Group

The research involved a heterogeneous group of more than 3,000 athletes (males), aged from four to forty years, who were competing in a variety of sports (ice hockey, bandy, basketball, football and futsal) as well as 266 (147 males, 119 females) non-athletes.

2.4 Statistical Analysis

Statistical analysis was performed with the use of statistic software MS Excel. We used descriptive analysis of the obtained data. Mean value (M), standard deviation (SD), minimum and maximal values of the measured parameters were calculated.

Co-Star test is a new technology with no average data for athletes of different sports and different age groups. To establish the levels of Co-Star results M ± 2/3 SD (25th percentile and 75th percentile) were calculated. The indicators between 25th and 75th percentiles were considered as average level. The visuomotor reaction time less than M - 2/3 SD (75th percentile) was assumed as strong or an Athlete's norm.

3 RESULTS & DISCUSSION

The Co-Star results reflect the ability to perform fast motor actions (speed), the ability to quick navigation in space (motor and coordination skills).

3.1 Co-Star Results of Athletes & Non-Athletes

As a result of the achieved standardization of Co-Star testing, it became possible to form databases of visuomotor coordination in groups of athletes and non-athletic individuals. Non-athletes are represented by students and university staff. Age from 19 to 35 years (Table 1).

Table 1: Co-Star results of non-athletes, ms.

	M±SD	min-max
Male (n=147)	1148±126	820–1500
Female (n=119)	1237±134	900–1630

Women exhibit lower level of visuomotor coordination, which is a female gender feature (Murray et al., 2018).

The results of Co-Star tests of professional athletes (ice hockey players, basketball players, soccer players and futsal players) aged 19-35 years (Table 2) are much better than non-athletes' Co-Star results.

Table 2: Co-Star results of professional athletes, ms.

Sport	M±SD	min-max
Ice hockey (n=60)	980±22	850–1020
Football (n=26)	1150±24	1020–1170
Futsal (n=29)	1010±34	990–1050
Basketball (n=35)	1020±36	980–1060

The research revealed significant differences in visuomotor coordination in professional athletes of different kinds of team sports (Table 2). The Co-Star results much depend on particular sports requirements (Zakharova et al., 2019).

In ice hockey a faster reaction and, accordingly, visuomotor coordination are required due to the higher speed of the puck and the players in comparison to the players and the ball in football.

Visuomotor coordination results of futsal and basketball players are very close to each other: futsal and basketball are similar in terms of the speed of change in the game situation and ball movement.

For basketball players a comparative test we conducted: the first two attempts were done as the standard test and then 2 attempts were fulfilled with dribbling (Figure 8).

Figure 8: Co-Star basketball dribbling test.

Table 3: Co-Star results of basketball players, ms.

	M±SD	min-max
Standard test (n=35)	1020±36	980–1060
Co-Star dribbling test (n=35)	980±47	910–1050

The basketball players (Table 3) demonstrated a higher dribbling performance compared to the standard Co-Star test. This can be explained by the fact that in the process of controlling the ball, the senses of a professional basketball player become more acute, and his neuromuscular connections are maximally activated to fulfill the test task. Co-Star dribbling test result indicates a high level of dribbling skills among basketball players and can be used as an objective indicator of their technical readiness.

After conducting a significant number of tests (the total number of participants of the research was more than 3,000 of different ages undergoing sports training in game sports), the age norms for the Co-Star test were formed (Table 4).

Table 4: Co-Star results evaluation criteria for team sports players of different ages, ms.

Ages	Average	Strong
4-6	2300–1900	<1900
7-10	1890–1520	<1520
11-14	1510–1100	<1100
15-19	1090-950	<950
20-35	940-850	<850
35+	1100–1270	<1100

The level of visuomotor coordination steadily increases until the age of 20, which coincides with the growth and development of the athlete as well as the improvement of their sport skills.

Athletes after 20+ demonstrated stable good level of visuomotor coordination in the Co-Star test.

After the age of 35, however, indicators of visuomotor coordination tend to decrease due to age-related physiological changes in athletes, requiring further study.

As Co-Star was designed for the field test it can be also provided on ice (Figure 9).

Figure 9: Co-Star ice test.

4 CONCLUSIONS

Co-Star is informative and reliable method of spatial visuomotor coordination assessment. Originality of test and measurement design easily supply a coach with valuable information about complex athletes' abilities (response time and the ability to coordinate the body segments quickly and precisely) which are of great value in team sports.

Despite the fact that the Co-Star study is at the initial stage, the obtained results can be useful for sport scientists and sports training specialists for sport selection, training management and coordination control.

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