Modern Light Sport Training Systems: "Co-Reaction" Neuromuscular Warm-Up

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Abstract: Warm up is an irreplaceable part of sport training. Traditional pre-competition warm-up is fulfilled automatically and therefore do not activate the brain in the way that is needed for excellent performance especially in sprint or first minutes of team sports game. There is no objective assessment of the warming up effectiveness and current state of the athlete. The aim of the study was twofold: to substantiate pre-competition brain warm-up using modern light sport training systems and suggest the method of objective assessment of warm-up efficiency in sport. The innovative Co-Reaction sports system, including the Blazepod™ Trainer with 6 sensors, the Blazepod™ software installed on a smartphone or tablet with Co-Reaction add-ons, and the Co-Reaction Desk, can provide rapid neuromuscular activation to athletes before competition. The results of Co-Reaction (visual-motor two-colour reaction time) allow to assess a current state of an athlete during the pre-competition warm-up. Comparison of the current result with the average earlies ones will give feedback on the athlete readiness/unreadiness and sufficiency/insufficiency of the warm-up. The article presents average data of Co-Reaction time and athletes' norms for different sport and Co-reaction results ages features of ice-hockey players.

1 INTRODUCTION

The importance of warm-up in sport as a method of physiological preparation for strenuous physical activity is undeniable. General warm-up tasks are temperature evaluation and movement range improvement to enhance performance and reduce the risk of injury.

Furthermore, warm-up can evoke neural and psychology-related effects (Lutz et al., 2024). Brain warm-up in sport is a new area of knowledge, although in fitness industry there are smart fitness and neurobics with exercises that are designed specifically for training the human brain: developing and improving memory, brain nutrition for improving performance (Danilov, 2010, Breaker, 2011, Smith, 2021).

Team sports are very demanding for speed and coordination of each teammate without exception. Success in team sport competition largely depends on the level of these abilities in players. Athlete's speed is born in their brain (Schonbrun, 2018, Smith, 2021, Lienhard, 2019, Lienhard, 2021).

One can imagine the work of the nervous system and the brain in the form of three consecutive stages:

a. receiving incoming signals from sensory systems;

b. analysis of incoming info and interpretation;

c. the generation of a response by movement or other means.

Using light sport training systems in exercises happens exactly according to this algorithm (incoming info −analysis −response) only with higher intensity due to quick flashes of colors in different places.

Pre-competition warm-up is vital for the optimal performance (McGowan et al., 2015, Lutz et al., 2024). But there are no objective methods to evaluate pre-competition warm-up effectiveness. On one hand, athletes and coach know what to do before the competition, on the other hand, routine warm-up can be ineffective or insufficient.

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The scientific problem is how to activate the athletes’ brain during pre-competition warm-up?

The aim of the research was twofold: to substantiate pre-competition brain warm-up using modern light sport training systems and suggest the method of objective assessment of warm-up efficiency in sport.

The method we propose accomplishes the following tasks: not excluding, but complementing the classical warm-up, it allows for neuromuscular activation; obtain objective data on the current state of the athlete's response speed and track the dynamics of changes to adjust the process of pre-competition warming-up.

2 METHODS

To provide the presentation of light sport system method for neuromuscular acceleration three main aspects were selected: description of device, receiving data process and the way of data analysis.

2.1 Blazepod Sensors Description

The Blazepod™ (based on RGB LED-technology, Bluetooth™ technology) trainer (Israel, Thailand) designed for diversification of sport training was selected for our research. Cylinder-shaped Blazepod sensors have 100 mm in diameter and 42 in height (Ezhov et al., 2021). Thanks to their form sensors can be located in the housing case or for charging one after the other, slightly recessed into one another (Figure 1).

Figure 1: Blazepod 6 sensors version.

2.2 Co-Reaction Method

For brain warm-up we developed a system that we called Co-Reaction (Coordination + Reaction).

6 sensors were placed on the table according to a scheme (Figure 2). The smartphone or tablet PC according Blutooth™ must have the Blazepod™ program installed with our Co-reaction add-ons.

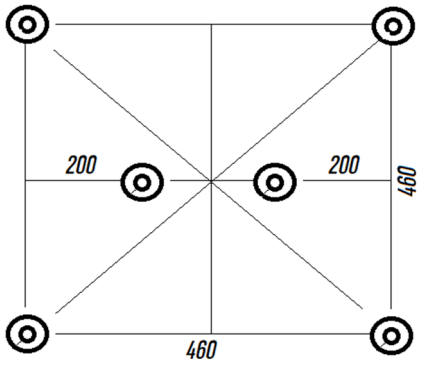

Figure 2: Co-Reaction sensors scheme.

Participants were instructed to deactivate the target yellow light sensors as fast as possible with a hand by soft touching. After starting the Co-reaction program with the "GO" command two sensors of six simultaniously were activated - the target color (yellow) and the interference color (violet).

The smartphone records the deactivation time of the target sensor and immediately (in 0.001 s) activates the next pair of yellow and violet colours.

Next light sensors pair were activated randomly during 30 seconds in a trial. The analysis concerned the mean deactivation time (reaction time) of the target sensor in Co-reaction test.

2.3 Statistical Analysis

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

Co-Reaction as a test is a new technology with no average data for athletes. To establish the levels of, level criteria was calculated using the value of the normal M and the deviation equal to ± 2/3 SD:

• Average level – the indicators in the range M ± 2/3 SD;

• Level above the average (Athlete’s norm) the indicators are greater than M - 2/3 SD.

3 RESULTS & DISCUSSION

3.1 How Co-Reaction Works

The impact of Co-Reaction on an athlete reacting to a

bright flash of light with a quick and precise hand movement has the following effects:

a. activates vision due to the high speed of eye movement looking for target sensor;

b. activates the occipital lobe of the brain, which is responsible for analyzing details such as clarity and color;

c. activates the temporal lobe of the brain to recognize active stimulus;

d. activates the parietal lobe of the brain to determine the target stimulus;

e. activates the frontal lobe and cerebellum, which are responsible for the accuracy of the impact on the stimulus;

f. due to the high intensity of the exercise, activation of the neuromuscular connections of the "eye-brain-hand" is achieved.

3.2 Co-Reaction Desk Development

Carrying out the proto- Co-Reaction test revealed the following problems:

a. the sensors shifted, changing the distance between them and even flew off the table, thus caused errors in the results;

b. the sensors turned over, which made it impossible to deactivate the sensor;

c. sensors occasionally failed to work (were not deactivated by hand blow) on a hard surface, thereby increasing the response time.

Among the Blazepod™ accessories there is no option that would help to improve the above-mentioned situation.

To solve these unpleasant problems, it was proposed to use a desk with a fixed location of sensors. Desk 600 x 600 mm was made of eva-materials, with 6 conical holes Ø 95 mm.

Further development of the eva-desk made it possible to make it foldable (Figure 3).

To improve actuation of Blazepod's sensors (problem **c**) one may use a 2-3 mm thick substrate or soft plyoboxes. Vibration-absorbing materials of soft plyobox sides significantly reduce the problem.

Co-Reaction desk making allowed us to provide standard conditions for "hand-eye" coordination (Zakharova et al., 2019).

3.3 Co-Reaction

The innovative Co-Reaction sports system includes the Blazepod™ Trainer with 6 sensors, the Blazepod™ software installed on a smartphone or tablet with Co-Reaction add-ons, and the Co-Reaction Desk.

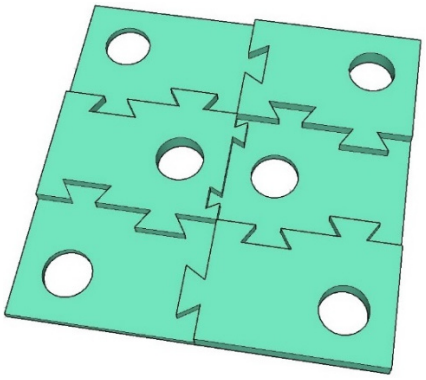

Figure 3: Co-Reaction Desk.

The first stages of Co-Reaction use (Figure 4) showed that this system fully complies with the requirements of tests. Co-Reaction test is standardized, reliable and valid.

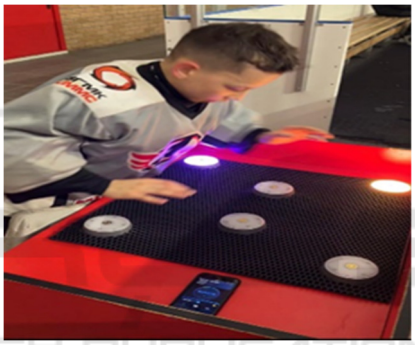

Figure 4: Co-Reaction warm-up before official game.

3.4 Co-Reaction Results in Athletes

The creation of Co-Reaction test made possible to form databases of visual-motor coordination in groups of professional athletes and calculate mean value and athlete's norm in different kinds of sports (Table 1). Professional athletes aged 19 to 35 took

Table 1: Co-Reaction results of professional athletes, ms

Sport	M±SD	min-max	Athlete's norm
Ice hockey (n=98)	332±22	310 −355	<325
Football (n=26)	440±24	414−480	<420
Futsal (n=14)	380±34	335−405	<370
Cross-country skiing (n=14)	462±36	385 −502	<440

part in the research. All athletes whose results are listed in Table 1 have a high level of athletic skills and are members of professional sports leagues.

Co-Reaction values of professional athletes correspond to the specifics of team sports: team sport players are quicker in reaction than cross-country skiers. Next, hockey is the most demanding game sport in terms of speed of response, and ice hockey players are the fastest athletes in Co-Reaction.

To identify age-related characteristics of Co-Reaction results, a research was carried out in ice hockey sports schools as well as in regional ice-hockey teams of all ages and professional league teams in 2021-2025. Amateur ice-hockey athletes 40+ were represented by winners of the all-Russian amateur competition NHL (Night Hockey League) in 2023 (Zakharova et al., 2023) and regional NHL winners in 2024.

Co-Reaction age features in ice hockey players from 14 years old till 35 revealed the gradual improvement (Table 2) with ages.

Table 2: Co-Reaction age features in successful ice hockey players, ms.

Age	M±SD	max-min	Athlete's norm
14 (n=169)	457±36	421-494	<430
15 -16 (n=217)	432±40	389-476	<410
17-19 (107)	416±24	392-440	<400
20 -35 (198)	332±22	310-355	<315
40+ (43)	433±41	392-475	<405

In takes 30 seconds to carry out Co-Reaction test thus providing quick and objective assessment of the speed of visual-motor coordination that can be compared with the norm values in sport: age athlete's norm, teammates average or the athlete individual average result.

As quick assessment of game situation and adequate game decision are of great importance in team sports athlete's norm may be used for team sport selection too.

Co-Reaction warm-up was carried out in professional ice-hockey team of Continental Hockey League throughout the season 2023/2024. This longitude research in the professional ice-hockey team revealed a positive pattern of Co-reaction: increasing pace at the beginning of the season, stabilization in the middle of the season and personal best Co-reaction values in playoff games (Figure 5).

During 10 months the ice-hockey player with stable athletic performance demonstrated stable increasing Co-Reaction results, as depicted at figure 5, where on the top axis the game number were represented.

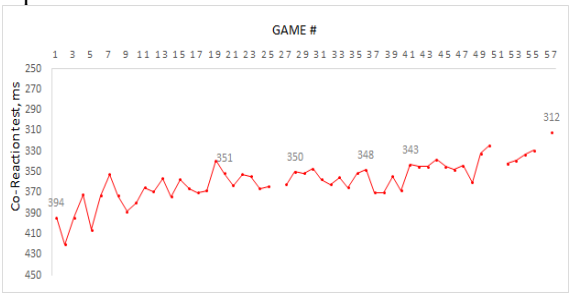

Figure 5: Professional ice-hockey player's individual Co-Reaction graph in competition season 2023/2024.

We consider that the improvement of Co-reaction results is more related to improved athlete's fitnes than to addictiveness in terms of motion automation, especially due to the random activation of pair of sensors.

The warm-up with the use of Co-Reaction before the official matches of both professional and youth teams allowed to:

a. find out the insufficiency of warm-up: if the demonstrated pre-competition Co-Reaction is worse than the individual Co-Reaction data frames, then the warm-up has not fulfilled its tasks, that is, the athlete is not ready for the match and should activate himself with additional exercises;

b. confirm the performance readiness by personal excellent Co-Reaction result;

c. reduce pre-start anxiety according to the athletes' opinion thanks to the game form of Co-Reaction warm-up.

In 80% the use of Co-Reaction warm-up led to a quick score or effective action in the first 3 minutes of the match.

Feedback from the athletes of the professional ice hockey teams revealed that 75% of the players are ready to use Co-Reaction daily during the warm-up process, as they feel the real positive effect. The similar position was supported by 90% of the coaches interviewed.

All the above-mentioned positive outcomes of using Co-Reaction in pre-competition warm-up prove the possibilities as well as the effectiveness of Co-Reaction in sport.

4 CONCLUSIONS

Theoretical and practical analysis of the warming-up process in sport has shown the need for a cerebral (neural, neuromuscular) warm-up in pre-competition

training. The proposed Co-Reaction testing system based on the modern light sport training system Blazepod™ has shown high efficiency in activating the brain, which in addition to the standard warm-up gives additional positive effect. Without interfering with the traditional pre-competition warm-up Co-Reaction neuromuscular warm-up provides several benefits:

1. It activates the brain, thereby increasing the excitation of the nervous system, which helps the athlete to get involved in the game faster, namely, to react quicker and more accurately to the sport game situation.

2. It brings variety into the ordinary, sometimes monotonous preparation for competition.

3. It helps relieve pre-competition jitters by shifting focus to a game form task of Co-Reaction.

In addition to warming up the neuromuscular system, Co-Reaction system provides visual, objective information that can be used for operational control by coaches and athletes.

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