Artículo original / Original Article

AGREEMENT AND RELIABILITY OF A NEUROMUSCULAR AND COGNITIVE TEST BASED ON LIGHT STIMULI TO ASSESS INTEGRATIVE REACTION TIME IN SPORTS

Concordancia y confiabilidad de una prueba neuromuscular y cognitiva basada en estímulos de luz para evaluar el tiempo de reacción integrativo en el deporte

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Abstract

Reaction in team sports involves a series of systemic processes integrating functions to develop a response considering situation, time and space. The aim of this study was to analyze the agreement and reliability of a neuromuscular and cognitive test based on light stimuli to assess integrative reaction time in sports. Fourteen active participants performed two sessions with 10 repetitions of the NeuroPhys Sport Reaction Test (NPSRT). The test showed moderate to almost perfect reliability (intraclass correlation coefficient= 0.53-0.81) and good agreement (Bland-Altman Method, BIAS= -0.0004-0.029) between sessions; there were no absolute mean differences between sessions (repeated measures t-test= $p \leq 0.050$) and presented moderate to high lineal correlations (Pearson r= 0.53-0.83, $p \leq 0.05$). The NPSRT could be considered as a reliable test to assess reaction time in team sports.

Keywords: reaction; assessment; cognition; team sport; test.

Resumen

La reacción en los deportes de equipo implica una serie de procesos sistémicos que integran funciones para desarrollar una respuesta considerando la situación, el tiempo y el espacio. El objetivo de este estudio fue analizar la concordancia y la confiabilidad de una prueba neuromuscular y cognitiva basada en estímulos de luz para evaluar el tiempo de reacción integrativo en los deportes. Catorce participantes activos realizaron dos sesiones con 10 repeticiones de la Prueba de Reacción Deportiva NeuroPhys (NPSRT). La prueba mostró confiabilidad moderada a casi perfecta (coeficiente de correlación intraclase = 0.53-0.81) y buena concordancia (Método Bland-Altman, BIAS= -0.0004-0.029) entre sesiones; no hubo diferencias medias absolutas entre sesiones (prueba t de medidas repetidas= p≤ 0.050) y presentaron correlaciones lineales moderadas a altas (Pearson r= 0.53-0.83, p≤ 0.05). El NPSRT podría considerarse como una prueba confiable para evaluar el tiempo de reacción en los deportes de equipo.

Palabras claves: Reacción; evaluación; cognición; deporte de equipo; prueba.

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Introduction

Technology is playing an increasing and fundamental role in performance enhancing in team sports (Loland, 2001). Nowadays, due to accelerated technological advances, scientific equipment has been developed with high validity and reliability and with increasing accessibility both economically and in the data mining and analysis (Oliva-Lozano et al., 2020). Considering that the control of this type of variables during all stages and scenarios of the sports process is fundamental. It is necessary to create valid and reliable evaluation methods that allow expeditiously to have information for real-time decision making (Rojas-Valverde, Gómez-Carmona, Gutiérrez-Vargas, & Pino-Ortega, 2019).

In this sense, multiple portable devices for the assessment of both external (physical) and internal (physiological) workload variables have been developed (Svilar, Castellano, & Jukic, 2018; Vázquez-Guerrero, Suarez-Arrones, Casamichana Gómez, & Rodas, 2018). These variables can be neuromuscular, cardiovascular or neurocognitive. The portable feature of this type of advanced measuring equipment allows the monitoring of performance indicator variables in sports remotely and without negatively influencing on sports performance (Jones, Hesford, & Cooper, 2013; Tanner, Fuller, & Ross, 2010; Waldron, Twist, Highton, Worsfold, & Daniels, 2011). One of the fundamental variables to quantify in indoor team sports such as handball, basketball and futsal is the intensity at which the different actions are carried out during training and competition (Gutiérrez-Vargas, Gutiérrez-Vargas, Ugalde-Ramírez, & Rojas-Valverde, 2018; Naser, Ali, & Macadam, 2017; Pino-Ortega et al., 2019).

The intensity in the sport is based on physical and cognitive components. Physical variables such as speed, sprints, accelerations and decelerations, changes of direction among others such as the ability to maintain these maximum efforts without the presence of the effects of fatigue are important for the performance (Kellmann, 2010; Rojas-Valverde et al., 2018; Sonderegger, Tschopp, & Taube, 2016). These physical load variables have been widely studied as performance indicators (García, Ibáñez, Martinez De Santos, Leite, & Sampaio, 2013; Parmar, James, Hearne, & Jones, 2018; Rojas-Valverde, et al., 2019; Rojas-Valverde et al., 2015). The processes cognitive like attention, anticipation, decision making and reaction capacity are the start point in the performing and maintenance of motor actions during competitions (Appelbaum & Erickson, 2018), but there is a gap in the knowledge of how these variables influence global aspects at a technical, physiological and tactical level (Clemente, 2018; McLaren et al., 2018; Svilar et al., 2018; Weaving, Marshall, Earle, Nevill, & Abt, 2014).

The integration of the physical and cognitive components are essential in team sports because allow the ordering, positioning and decision making when carrying out actions such as marking, demarcation, creation of spaces, blockages, among other actions that not only involve a physical aspect but also a great cognitive and perceptual component (Paul, Gabbett, & Nassis, 2016). In sports as handball, basketball and futsal, very high intensity actions are executed in a relatively small space where there are many stimuli such as size, speed and position of the rivals, target-background contrast, ambient lighting, speed of the athlete, public, deceptive actions, among others (Güldenpenning, Kunde, & Weigelt, 2017). These stimuli can cause difficulties in tactical execution in an optimal way because the complexity in the interaction of individual, dyad and group tactics (Araújo et al., 2015). For the optimal execution and tactical ordering during this type of sports, the development of temporal space perception skills such as visual perception and reaction speed with the lower cognitive effort possible is critical (Cardoso, González-Víllora, Guilherme, & Teoldo, 2019). In indoor sports, for example, the visual-motor strategy used can be indicative of complex cognitive development, decision making and rapid execution of actions during the game (Bijman, Fisher, & Vallis, 2016). This ability is trainable and can be improved through techniques that promote the integration of both variables in scenarios as closely attached to the reality of the game as possible.

Based on the above, a novel term has been proposed that integrates a component of the physical load such as the reaction time and a cognitive aspect such as decision making. When trained together this both elements have been called integrative physical and cognitive training. This new method allows athletes, coaches and sport scientist to develop activities and training programs that could simulate real settings using global and specific conditioning activities using multitasking training (Myer et al., 2011). This multitasking activities usually integrate visual and auditive commands when the athlete is developing some general actions as fundamental movements (e.g. running, changing directions, accelerating, jumping and others).

In response to the above, stimulation tools have been created with a high component of visual perception (Murray & Hunfalvay, 2017; Savelsbergh, Williams, Kamp, & Ward, 2002) that can be integrated with physical demand and cognitive decision-making activities. Some devices uses flashing lights stimuli in order to achieve this ability development, this is the case of tools such as: Octupus Trainer, AcuVision 2000, Vision Coach, Dynavision D2, Visual Stick-UpsWayne, Batak, Makoto Arena, Sicropat and FitLigth Trainer (Pérez-Godoy, 2013). These tools could become a fundamental tool in the visual-motor strategy used, selective attention and expertise in sports considering experienced players usually have better visual-motor strategies than lower experienced players that allow them to better response to an stimuli (Williams & Davids, 1998).

Due to the high variability of activities that can be developed with this type of instruments, it is difficult to carry out validation studies of these mentioned instruments. Almost always these validations are framed in a specific test developed for an isolated activity. In consequence, the aim of this study was to analyze the agreement and reliability of a neuromuscular and cognitive test based on light stimuli to assess integrative reaction time in team sports.

Methods

Participants

Twenty-one male healthy (age 22.9±2.72 years, height 168.7±12.62 cm, weight 68.35±12.62 kg) and active (>150min per week, 3.4±3.5 h per week) participants took part in the study. They were advanced and trained physical education students with a sport experience of 3.8±5.43 years, with no injuries, neurocognitive conditions or visual impairments. The protocol for this study was reviewed and approved by the Committee of the School of Human Movement and Quality of Life Sciences and a written consent was signed by all participants and the protocols of the study were conducted according to biomedical principles of Declaration of Helsinki (2013).

Procedures and devices

Participants took part of two familiarization sessions prior testing, followed a week after, by two tests divided by a day (see figure 1). Regular running 15min warm up was performed before each test. The rest time between test.

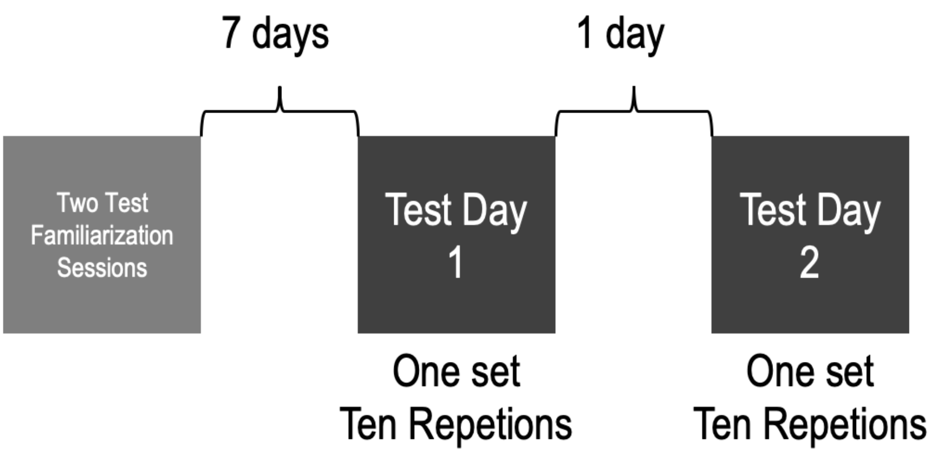

Figure 1. Study chronology design.

NeuroPhys Sport Reaction Test (NPSRT) was performed using a wireless reaction system composed of five programable LED lights (FitLight Trainer™, Miami, FL). NPSRT consist in a neuro cognitive and muscular reaction time test, involving situational analysis, cognitive and visual processing, decision making and neuromuscular reaction and contraction time.

Five lights were fixed in a semicircle using tripods at hip height (see setting in figure 2), each light was positioned five meters far from start point and each 45º degrees from start point as shown in figure 2. After the running based warm up the total sample was asked to take start position. Participants were asked to begin at starting position, after researcher signal, the test started and lights began to randomly flashes until the participants turn them off, running through a laser with 80 cm range (red lines in figure 2). There was a total of ten repetitions, and one sets, each light flashed twice per set, so the participants turned off a total of ten lights (two in each position). There was a rest time of 10-15 s between the lights, so the participant had enough time to recover initial position, prepare and waits the next light flashes. The test required that lights were turned off at fast as the participant could.

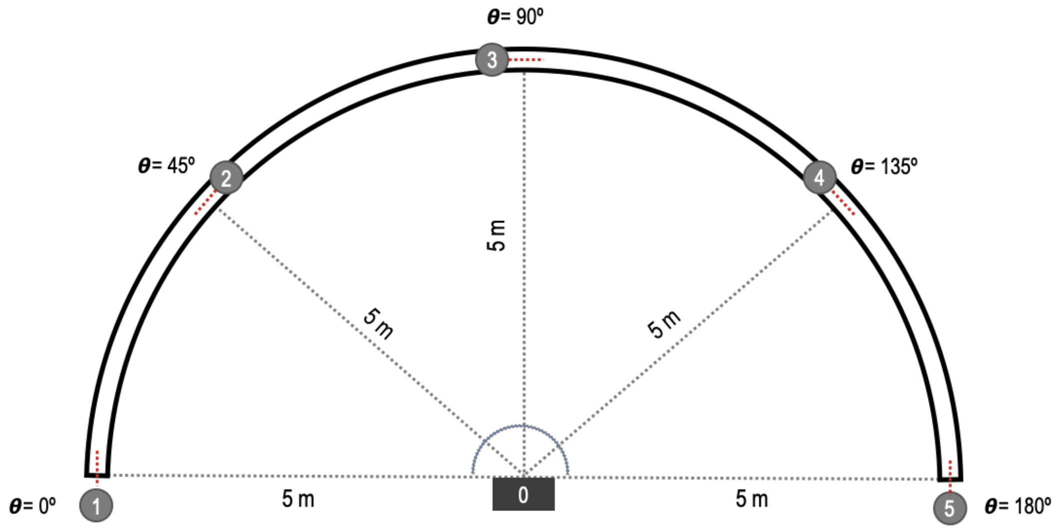

Figure 2. NeuroPhys Sport Reaction Test setting. 0. Starting position. 1-5. Lights position

Both tests were performed in an insulated indoor court with light restriction to allow the participants to see lights stimuli as better as possible; familiarization sessions and tests were conducted in the same court and at the same day time. No sound start signals were used, visual and auditive distractions were reduced as minimum. There was no motivation from coaches or researchers, and they were placed behind starting point to reduce distractions.

Participants were asked to avoid intense physical activity at least 24h prior tests, and avoid neuro-depressors (e.g. drugs, teas) or neuro-stimulators (e.g. caffeine, glucose) intake at least 3 hrs prior tests.

Statistical Analysis

The data is presented as means and standard deviation. Kolmogorov Smirnoff test was used to confirm the normality of the data, verifying the feasibility of using parametric inference. Over-time test consistency was assessed via reliability using intraclass correlation coefficient (*ICC*) with respective 95% *IC* and it was confirmed via lineal correlation between measurements. *ICC* was interpreted following previous proposed ranks as: 0 *poor*, 0.01-0.02 *trivial*, 0.21-0.4 regular, 0.41-0.6 *moderate*, 0.61-0.8 *substantial* and 0.81-1 *almost perfect* (Kramer & Feinstein, 1981). Bias and agreement between measurements was assessed using Bland Altman Plotting method with respective 95% *IC*; it was complemented by mean differences analysis between measurements using t-tests. Moreover, magnitude of the significance was assessed using Cohen's *d* effect size (Cohen, 1988), qualitatively rated as follows: < 0.2 *trivial*, 0.2-0.6

small, 0.6-1.2 *moderate*, 1.2-2 *large*, and 2.0-4.0 *very large* (Hopkins, Marshall, Batterham, & Hanin, 2009). All tests were performed following previous guidelines for agreement and reliability testing (Kottner & Streiner, 2011; Zaki, Bulgiba, Ismail, & Ismail, 2012). To analyzed possible differences between light´s position (º) a one-way analysis of variance for each test was performed. Statistical differences were considered if $p < 0.05$. Statistical analyses were developed using a special software (v.24, Statistic Package Social Sciences, Chicago, IL).

Results

Table 1 shows the absolute results of both test of NeuroPhys Sport Reaction Test. After one-way analysis of variance. There were found no differences between lights times in Test 1 ($F_{(4,68)}$= 1.796, p= 0.14) or Test 2 ($F_{(4,64)}$= 1.024, p= 0.402).

Table 1. NeuroPhys Sport Reaction Test absolute results comparation.

Variable	Sensor Position	*n*	Test 1	Test 2
NeuroPhysi Sport Reaction Test	1st (0º) (s)	48	1.96 ± 0.11	1.96 ± 0.13
	2nd (45º) (s)	48	1.99 ± 0.14	2 ± 0.15
	3rd (90º) (s)	50	2 ± 0.09	1.98 ± 0.1
	4th (135º) (s)	48	1.96 ± 0.11	1.95 ±0.12
	5th (180º) (s)	36	1.96 ± 0.12	1.96 ± 0.12
	1st - 5th (0-180º) (s)	218	1.97 ± 0.11	1.98 ± 0.13

Note: Date are presented as mean ± standard deviations; n= observations; s= seconds

Table 2 shows the results of reliability and agreement of NeuroPhys Sport Reaction Test. There were found moderate to almost perfect reliability and good agreement between test in all light positions. There were significant and moderate to high lineal correlation between test in all lights. There were no differences in light times means (p> 0.05).

Table 2. Reliability and agreement of NeuroPhys Sport Reaction Test.

Variable	Sensor position	*n*	*ICC* (*rating*)	95% *IC*	*R* (*p* value)	Bias	95% *IC*	*t* (p value)	Cohen *d* (*rating*)
NeuroPhys Sport Reaction Test	1st (0º)	48	0.811 (*almost perfect*)	0.611; 0.914	0.832 (<0.01)	-0.029	-0,028; -0.086	-1.89 (0.071)	-0.27 (*trivial*)
	2nd (45º)	48	0.769 (*substantial*)	0.536; 0.893	0.77 (<0.01)	-0.004	-0,004; -0.012	-0.194 (0.848)	-0.03 (*trivial*)
	3rd (90º)	50	0.529 (*moderate*)	0.177; 0.761	0.53 (0.01)	0.029	0,028; 0.086	1.608 (0.121)	0.23 (*small*)
	4th (135º)	48	0.789 (*substantial*)	0.572; 0.903	0.793 (<0.01)	0.013	0,012; 0.039	0.877 (0.389)	0.13 (*trivial*)
	5th (180º)	36	0.603 (*substantial*)	-0.062; 0.851	0.615 (0.01)	-0.0004	-0,0003; -0.001	-0.012 (0.99)	-0.002 (*trivial*)
	1st - 5th (0-180º)	218	0.715 (*substantial*)	0.614; 0.793	0.721 (<0.01)	0.005	0,0048; 0.015	-0.671 (0.504)	-0.045 (*trivial*)

n= observations

Discussion

The aim of this study was to analyze the agreement and reliability of a neuromuscular and cognitive test based on light stimuli to assess integrative reaction time in team sports. There was found no differences between the time of integrative reaction of the tests between the two assessed tests. This suggest that the test could have good reliability and agreement considering that there were internal bias control before and during measurements as: familiarization sessions, insolated conditions and reduction of distractions, no intense physical activity before test was allowed. So, this could give information that in similar conditions, the test have the capacity to evaluate accord to the performance of the participants with consistency. The information could be supported by the high lineal correlation and low bias between test assessments in all lights.

In this sense, it could be conclude that the NeuroPhys Sport Reaction Test have almost perfect reliability and good agreement between test in all light positions considering the qualification criteria of all tests made (Cohen, 1988; Hopkins et al., 2009; Kottner & Streiner, 2011; Kramer & Feinstein, 1981).

This NPSRT could be considered a good assessment tool to explore the visual-motor strategy, selective attention and decision making as well as the performance during integrative multitasking activities during training. As exposed this capacity to analyzed multiple stimuli in a single test and react as fast as possible is fundamental in team sports (Bijman et al., 2016; Cardoso et al., 2019; Myer et al., 2011) due to the important role of the cortical integration of multiple stimulis (eg. neuromuscular reaction, visual reaction, visual strategies) to make an effective decision under random external stimulis. This could give information to the athletes, coaches, sport scientist, psychologist and other team staff members of the cognitive and physical ability of the athletes.

Limitations

While the results of this study have provided value information about the reliability and agreement of a new cognitive and neuromuscular reaction time test that could be applied by coaches and athletes, some limitations should be acknowledge. One of the main limitations was the sample size, results could be stronger in future studies if the sample size increases. For future analysis, the sample should be as homogeneous as possible considering sex and physical level, athletes' participants should be the best sample. Considering that this study was conducted under controlled conditions, some NPSRT variations analysis must be made under multi-stimuli scenarios that simulate more accurate the real training and competition conditions as in team sports.

Practical applications

The NPSRT showed the possibility to assess the complexity of reaction time considering the stimuli processing and neuromechanically response at all systemic levels of athletes. This test in conjunction with other field test (e.g. speed, sprints, decisions making tests, multitasking tests) could allow to discriminate between cognitive and physical reaction capacities of players. NPSRT have showed the in-field possibilities during training in order to improve the complex reaction time, considering it rapid evaluation, portability of the equipment and easy data analysis.

Conclusion

NPSRT is consistent over time (reliable) and showed good agreement between measures, so it represents a new assessment method of neuro cognitive and muscular reaction time. This test involves situational analysis, cognitive and visual processing, decision making, neuromuscular reaction and contraction time in the same test. Consequently, NPSRT could be used by coaches athletes, sport scientist and other sport professionals to assess integrative reaction time in athletes as well as to develop training that improve cognitive and physical reaction skills in athletes.

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