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Response time of athletes with different sports specializations

Jerzy Sadowski [1ADE], Igor Cieśliński [1CD], Dariusz Gierczuk[*2BDE]

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[1] Department of Sport and Training Sciences, Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education and Health in Biala Podlaska, Poland
[2] Department of Combat Sports, Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education and Health in Biala Podlaska, Poland
*** Corresponding author:** Dariusz Gierczuk, Józef Piłsudski University of Physical Education in Warsaw, Faculty of Physical Education and Health, 2 Akademicka Street, 21-500 Biala Podlaska, e-mail: dariusz.gierczuk@awf.edu.pl

Dictionary:

Response time – the measure of the time between the presentation of a stimulus and the completion of the movement response (reaction time plus movement time).

Reaction time – the measure of the time between the presentation of a stimulus and the initiation of a motor response.

Movement time – the observable movement; that is, the time from the initiation of the movement until it has been completed.

Simple reaction time – the time needed to react to a task with only one stimulus.

Choice reaction time – the time needed to react when there is more than one stimulus.

Athlete – noun 1. someone who has the abilities necessary for participating in physical exercise, especially in competitive games and races 2. a competitor in track or field events [64].

Player – noun someone taking part in a sport or game [64].

Abstract:

Background and Study Aim: Team sports and combat sports impose significant demands on visual and cognitive skills, as athletes often encounter situations requiring precise motor responses to visual stimuli. This aim of the study was to expand existing knowledge on how sport-specific experience affects response time to different stimuli in combat sports and team sports athletes.

Material and Methods: The research involved 261 highly skilled athletes from various areas: a) combat sports (n = 204): freestyle wrestling, Greco-Roman wrestling, ITF taekwon-do, WTF taekwondo; b) team sports (n = 57): basketball, handball, soccer, volleyball. The athletes were between 18 and 25 years of age, with a training experience of at least 6 years. A single measurement of response time, including simple reaction and choice reaction, was conducted using the Vienna Test System.

Results: Response time varied among athletes in different sports, with greater diversity observed in simple reaction than in choice reaction. Considering simple reaction time, the best results were noted among representatives of combat sports. Wrestlers and taekwondo athletes exhibited the shortest reaction and movement times. No significant differences in simple reaction and choice reaction times were found between athletes in different combat sports. Similar differences were observed among team sports players. When comparing combat sports and team sports, combat sports athletes demonstrated shorter response time (including reaction time and movement time), while team sports players showed shorter choice reaction time and higher accuracy in response to a given stimulus.

Conclusions: The specificity of sports training differentiates athletes with different sports specializations in terms of response time (simple and choice reaction times) to different stimuli. Long-term sports specialization exerts a positive influence on different types of reactions, which can have a beneficial impact on the safe functioning of individuals, including coping effectively with complex daily tasks..

Keywords: choice reaction, combat sports, INNOAGON, personal safety, simple reaction, team sports

INNOAGON (innovative agonology) – is an applied science dedicated to promotion, prevention, and therapy related to all dimensions of health and the optimization of activities that increase the ability to survive (from micro to macro scales) [49, 56].

Personal safety – a justified sense of survival ability in various emergency situations, either of external nature (e.g. violence, aggression, unintended fall, fire, tsunami) or internal nature (e.g. stress, disease, fear) [61].

1. Introduction

Team sports and combat sports impose significant demands on visual and cognitive skills, as athletes often encounter situations requiring precise motor responses to visual stimuli. Response time, i.e., the duration between stimulus presentation and response execution, is a crucial variable in sports, academics, and daily tasks [1-4]. It reflects the cognitive system's ability to process information efficiently [5], involving the sensorimotor cycle, which includes stimulus detection, information transfer through afferent nerves, central nervous system response generation, and final execution [6, 7]. Response time encompasses processing the stimulus, decision-making, and appropriate response execution [8].

Reaction time and movement time are classic measurements assessing athletes' information processing efficiency and sports skills performance [9-12]. There are three types of reaction time: simple reaction time, choice reaction time, and recognition reaction time [13, 14, 8]. Simple reaction time involves responding to a stimulus. Choice reaction time is a reaction corresponding to a specific stimulus [14, 8], while recognition reaction time involves reacting to certain stimuli and ignoring others [13]. Simple reaction times, involving lower processing demands, are faster than choice reaction times [15].

Various factors influence reaction time, including individual characteristics such as fatigue, physical condition, sports experience, motivation, gender, age, and dominance of the responding body part. Stimulus-related factors include the physical characteristics, intensity, and duration of the stimulus [16, 17, 9].

Reaction time plays a crucial role in sports and daily activities of people of different ages [18, 19, 3]. While some studies report inconclusive links between reaction time and sports experience [20], others indicate correlations, with faster reaction times observed in elite players compared to sub-elite or non-players [21-26]. Shorter reaction time in elite sports players has also been associated with improved performance on the field [27].

Despite uncertainties regarding whether shorter reaction time results from faster perceptual or motor-related processing, there is significant scepticism about the importance of shorter reaction time for elite sporting performance, even in time-critical situations. While some authors argue that faster reaction times are linked to elite performance and that explicit training can enhance reaction time, thus leading to improved sporting performance [26], an alternative and widely accepted perspective suggests that the elite advantage is rooted in their 'perceptual-cognitive expertise' [28, 29]. This expertise is partly based on knowledge of precisely where and when to focus to gather key information, allowing elite-level players to anticipate unfolding events and effectively plan and execute tasks. In challenging sporting scenarios, it becomes increasingly crucial that the gaze 'must be precisely controlled in space and timed relative to specific phases of the motor skill' [30].

Previous research suggests that physical activity and exercise can enhance cognitive functioning and attention [31, 32]. Individuals engaged in sports tend to exhibit better reaction times than their non-sport counterparts. Exercise has been linked to reaction time improvement, with a potential reduction of 0.12 seconds through technique changes [18].

Beyond the sports realm, quick reactions are crucial in daily functioning, where individuals must rapidly respond to various stimuli [33]. Reaction times, whether

innate or acquired through training, enhance an individual's sense of value and increase self-defence capabilities, not only in motor aspects (combat sports and hand-to-hand combat systems and exercises) but also in broader human defence potential [34].

This aim of the study was to expand existing knowledge on how sport-specific experience affects response time to different stimuli in combat sports and team sports athletes.

2. Materials and Methods

Participants

Two hundred and sixty-one highly skilled male athletes from combat sports and team sports volunteered to participate in the present study: a) combat sports: freestyle wrestling (n = 31, mean age = 22.55 ±2.16) 10.06 ±2.61 years of training; Greco-Roman wrestling (n = 54, mean age = 20.19 ±2.02) 8.02 ±2.17 years of training; ITF taekwondo (n = 58, mean age = 21.02 ±3.25) 9.74 ±2.92 years of training; WTF taekwondo (n = 61, mean age = 21.82 ±2.55) 10.11 ±2.63 years of training; mean age = 22.55 ±2.16) 10.06 ±2.61 years of training; b) team sports: basketball (n = 11, mean age = 21.91 ±1.30) 7.45 ±1.13 years of training, handball (n = 15, mean age = 22.53 ±1.51) 7.47 ±1.36 years of training, soccer (n = 17, mean age = 21.76 ±1.20) 10.35 ±1.87 years of training; volleyball (n = 14, mean age = 22.36 ±1.01) 7.00 ±1.11 years of training.

Selection criteria included age (18-25 years), training experience of at least 6 years, and participation in national-level sports competitions. The participants did not report any eye disorders over the previous three months. All participants were involved in the study voluntarily, and they delivered written informed consent prior to the commencement of the study. They could withdraw from the study at any stage without giving a reason.

Study design

Simple and choice reaction times were measured using the Vienna Test System (VTS) [35, 36]. The tests were conducted in the Psychomotor Laboratory during the last week of the pre-season period of the annual training macrocycle. A single measurement of response time was performed in the morning hours. A 10-minute break was employed between the tests.

Simple reaction and its components, i.e., reaction time and movement time, were assessed using the reaction time test (S1 version). Subjects sat in front of a monitor, placing the dominant hand's index finger on a rest key on the control panel. Upon seeing a yellow light on the monitor, the subject moved the finger to press the reaction key. The result consisted of three components: A1 – the median of sensor reaction time (the time gap between a stimulus and releasing the rest key, expressed in milliseconds); A2 – the median of movement time (the time gap between releasing the rest key and pressing the reaction key, expressed in milliseconds); A3 – the median of response time (the time gap between the beginning of a particular stimulus and pressing an upper key, expressed in milliseconds).

Choice reaction was assessed using the DT test (S1 version). While sitting in front of a monitor, the participant responded as quickly as possible to stimuli appearing on it with both upper and lower extremities. Five visual stimuli in the form of rings in white, yellow, blue, green, and red were presented. There were five reaction keys on

the control panel assigned to particular colors. The participant pressed the keys with the right or left hand. Additionally, white rectangular lights against a black background required pressing the right or left pedal with a leg. Furthermore, acoustic stimuli (high and low sounds) were associated with white rectangular keys (responding with one or both hands). The result consisted of three components: B1 – the number of correct reactions; B2 – the number of incorrect and missed reactions; B3 – the median of response time (choice reaction time) (in seconds).

Statistical analysis

A one-way analysis of variance (ANOVA) was used to evaluate the differences between the groups combat sports: freestyle wrestling, Greco-Roman, ITF taekwon-do, WTF taekwondo, and team sports: basketball, handball, soccer, volleyball). Partial eta squared (η2) effect sizes (es) were calculated for multiple comparisons. Result of the analysis of variance is monitored by the indicator (F). The estimation of the results is based on the following indicators: frequency (N, n); mean (M); standard deviation (SD or ±). Statistical significance was set at $p < 0.05$. Data were analysed using R Program and the rstatix library [37].

The collected data led to the consolidation of athletes from 8 groups. As a result, two groups were formed, labelled combat sports (n = 204) and team sports (n = 57).

3. Results

Considering response time, freestyle wrestlers, Greco-Roman wrestlers, WTF taekwondo athletes, and ITF taekwondo athletes had shorter reaction time (A1) than handball players. Freestyle wrestlers also had shorter movement time (A2) compared to handball players, basketball players, and soccer players. Similarly, ITF taekwon-do athletes showed shorter reaction time than handball players, basketball players, and soccer players, Greco-Roman wrestlers had shorter reaction time than handball players, and WTF taekwondo athletes had shorter reaction time than handball players. Considering response time (simple reaction) (A3), more favourable results were observed for freestyle wrestlers compared to handball players, basketball players, and soccer players. In the choice reaction task, significantly more correct stimuli (B1) were recorded for volleyball players compared to WTF taekwondo athletes (Tables 1, 2, 3).

Table 1. Response time of athletes in selected sports (M & SD).

Group	Simple reaction (ms)			Choice reaction		
	A1	A2	A3	B1 (n)	B2 (n)	B3 (s)
combat sports (n = 204)						
Freestyle wrestling (n = 31)	**230.7** ±22.6	**89.2** ±16.2	**319.9** ±33.5	**246.1** ±28.6	50.4 ±21.0	**0.71** ±0.06
Greco-Roman wrestling (n = 54)	236.5 ±28.6	101.0 ±21.1	337.4 ±38.5	239.7 ±31.8	**40.5** ±19.2	0.75 ±0.06
ITF taekwon-do (n = 58)	240.3 ±28.4	93.9 ±19.4	334.1 ±39.4	243.4 ±27.7	49.5 ±20.1	0.72 ±0.06
WTF taekwon-do (n = 61)	240.4 ±24.2	103.2 ±20.2	343.7 ±35.4	233.7 ±31.7	49.8 ±16.7	0.74 ±0.05

team sports (n = 57)						
Basketball (n = 11)	262.0 ±29.6	115.7 ±25.2	377.7 ±45.3	251.8 ±31.6	39.2 ±10.9	**0.7** ±10.06
Handball (n = 15)	275.0 ±34.8	124.4 ±20.9	399.4 ±47.5	249.9 ±35.4	**38.9** ±14.3	0.72 ±0.06
Soccer (n = 17)	**250.4** ±28.8	114.3 ±27.1	364.7 ±37.1	249. 1 ±20.1	46.4 ±23.4	0.71 ±0.07
Volleyball (n = 14)	250.9 ±30.1	**108.5** ±17.9	**359.4** ±33.8	**265.1** ±25.3	42.4 ±18.6	0.71 ±0.05

A1 reaction time; A2 movement time; A3 response time; ms milliseconds; B1 number of correct reactions; B2 number of incorrect and missed reactions; B3 response time (s)

Table 2. Response time (simple reaction time) of athletes in selected sports (M & SD).

Group	Simple reaction (ms)								
	A1	F	p (es)	A2	F	p (es)	A3	F	p (es)
Combat sports (n = 204)	237.8 ±26.5	26.7	*** (0.09)	97.5 ±19.7	35.2	*** (0.12)	335.3 ±37.3	47.3	*** (0.15)
Team sports (n = 57)	259.2 ±31.8			115.8 ±23.3			375.0 ±42.9		

A1 reaction time; A2 movement time; A3 response time; ms milliseconds; es effect sizes

Table 3. Response time (choice reaction time) of athletes in selected sports (M & SD).

Group	Choice reaction								
	B1 (n)	F	p (es)	B2 (n)	F	p (es)	B3 (s)	F	p (es)
Combat sports (n=204)	240.0 ±30.3	9.47	** (0.03)	47.2 ±19.4	3.25	(0.01)	0.73 ±0.06	5.47	* (0.02)
Team sports (n = 57)	253.8 ±28.3			42.0 ±17.9			0.71 ±0.06		

B1 number of correct reactions; B2 number of incorrect and missed reactions; B3 response time (s); es effect sizes

The most statistically significant differences (n = 11) were found between combat sports athletes and team sports players in terms of detailed indicators of the variable 'simple reaction time' in the relation of handball athletes to freestyle and Greco-Romano wrestlers and ITF taekwondo athletes. Between WTF taekwondo athletes, statistically significant differences concern reaction time (A1) and movement time (A2). In the case of basketball players and the same combat sports athletes, there are 6 statistically significant differences. Soccer players are inferior ($p < 0.01$) to freestyle wrestlers in terms of movement time (2) and response time (A3), but only in terms of response time ($p < 0.05$) (Figure 1).

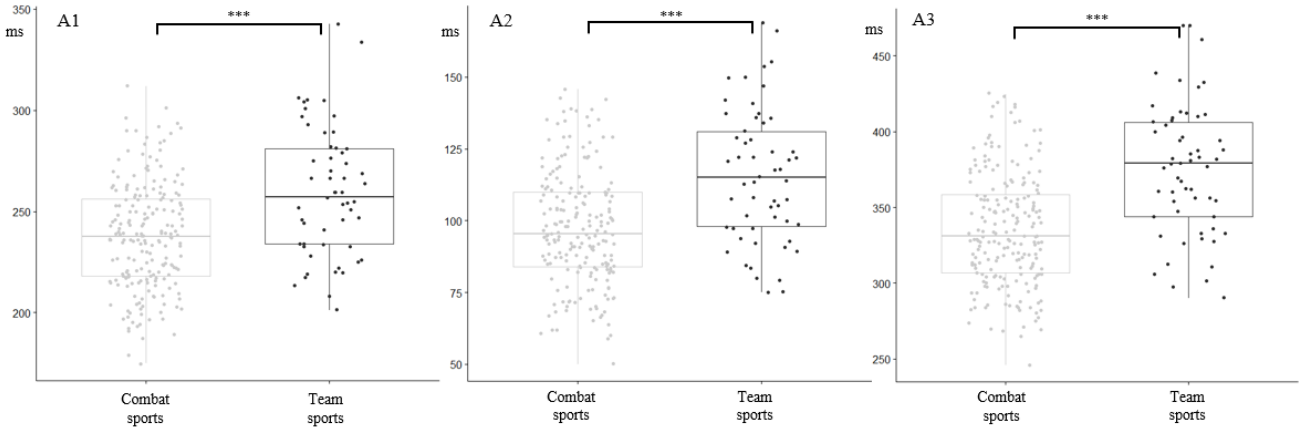
ANOVA revealed no statistical differences in both simple reaction and choice reaction times between the athletes from combat sports groups and between the athletes from team sports groups.

Freestyle wrestling	A3	***			**			**		
	A2		***			*			**	
	A1			***						
Greco-Roman wrestling	A3	***			*					
	A2		**							
	A1			***						
ITF taekwon-do	A3	***			*					
	A2		***			*			*	
	A1			***						
WTF taekwondo	A3				***					
	A2		*							
	A1			**						
Group		A3	A2	A1	A3	A2	A1	A3	A2	A1
		Handball			Basketball			Soccer		

*p <0.05; **p <0.01; ***p <0.001

Figure 1. Significance of differences in simple reaction time between athletes from different groups

Athletes in combat sports demonstrated shorter response time (A3) than team sports players (F = 47.3; es = 0.15) (Figure 2). Significant differences were noted in both reaction time (A1) (F = 26.7; es = 0.09) and movement time (A2) (F = 35.2; es = 0.12).



***p <0.001

Figure 2. Simple reaction time of athletes from different sports

In choice reaction (Figure 3), the number of correct reactions (B1) was higher in team sports athletes than in combat sports athletes (F = 9.47; es = 0.03). The number of incorrect and missed reactions (B2) was similar for athletes in both groups (F = 3.25; es = 0.01). Response time (choice reaction) (B3) was shorter in team sports athletes than in combat sports athletes (F = 5.47; es = 0.02).

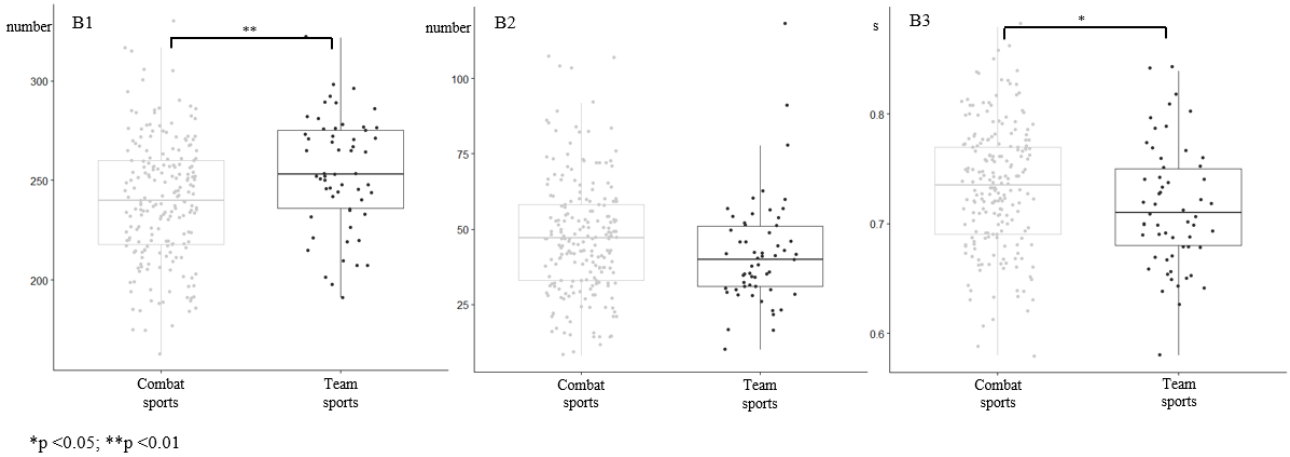


Figure 3. Choice reaction time of athletes from different sports groups

4. Discussion

The level of assessed response time differs between athletes in various sports. Greater variability in results was noted in simple reaction than in choice reaction.

When analysing simple time, the shortest reaction time was observed in wrestlers and taekwondo athletes. Similar results were obtained in movement time. No significant differences were found in simple reaction time between athletes in different combat sports and within team sports players. Considering simple reaction time, the most favourable results were observed in representatives of combat sports. However, the specific nature of sports training differentiates athletes in combat sports and team sports in the context of simple reaction time. Combat sports, such as boxing, karate, taekwondo, and judo, are defined as interceptive sports, in which athletes must coordinate and interact with external opponents [38, 39]. These sports are characterized by sudden environmental changes, requiring athletes to adapt to new situations in every moment [40, 12]. In addition to strength, endurance, and speed, the ability to process information is crucial for making appropriate decisions to win the fight. Achieving the goal in these sports is particularly challenging due to the short distance between athletes and the different strategies that can be adopted to deceive the opponent. For instance, fighters could plan to expose a part of their own body and invite the opponent to hit it, while they are hiding that they are going to release a counterattack [41, 4, 29].

In choice reaction, team sports players demonstrated the shortest response time, with the highest number of detected correct stimuli. The ability to select stimuli and understand others' actions is crucial in many aspects of our lives, particularly in sport, where it plays a significant role in winning the game. These abilities underlie perceptual-cognitive skills that encompass various cognitive functions, such as attention, visual discrimination, anticipation, problem-solving, and decision-making [6, 7]. Athletes must shift their attention to the key points, select and extrapolate useful information from the environment, and understand the future actions of opponents and teammates. For instance, basketball or soccer players need to rapidly comprehend their surroundings as they are required to make optimal decisions, such as deciding whether to anticipate their opponent's movement or wait for them to approach the final goal. In achieving this, athletes seem to concentrate, analyse, and

recognize subtle kinematic indicators well in advance of any action being executed [42, 43].

The time taken for the response selection phase is extended when the difficulty of analysing the task increases [10]. In sports, this is evident since the ability to analyse movements or situations is associated with sport-specific knowledge and experiences. Williams et al. [44] stated that sports experts can better predict opponent movements by rapidly detecting cues that precede the movement. The ability to anticipate future movements helps players detect cues based on opponents' movements. The player must stay vigilant, anticipate, and make swift and effective decisions to execute accurately calculated moves within shorter time frames. Moreover, the capacity to anticipate helps in reducing the time taken for the response selection phase, as it narrows down the choices of movements the player needs to consider. Consequently, it is logical to expect an increase in reaction time when players receive limited information, particularly in situations demanding responses to brief, momentary movements that do not afford players the opportunity to predict actions in advance. Shortening the time of the response selection phase can be achieved by reducing the time taken to analyse the situation, which is based on specific, relevant experiences [45, 10].

Physical exercise and the development of physical condition may have an impact on reaction time, directly by training the capacity to respond to a given stimulus and indirectly by influencing cognitive functioning [46, 47]. This impact may contribute to a greater sense of self-esteem in both the sports dimension and a person's ability to cope with various problems in everyday life unrelated to sports competition [34]. This is particularly evident with regard to utilitarian values [48]. Based on the theory of agonology concerning the theory of combat, it can be observed that quick reaction developed through sports training in combat sports (primarily simple reaction) and team sports (mainly complex reaction) can contribute to making appropriate decisions in situations threatening human health or life [49]. Various situations related to participation in road traffic, both from the perspective of a pedestrian and a vehicle driver, require a quick assessment of the situation and, in order to avoid danger, the execution of appropriate actions. The experience gained during sports training is also essential in other life-threatening situations, including avoiding or mitigating the effects of falls, or taking proper action when defending life or property [50-52]. The data obtained align with contemporary trends in activating older adults in the area of physioprophylaxis and preventing lifestyle diseases, ultimately improving health and overall well-being in senior age [53].

Although the cognitive limitations of these studies are obvious, they show the importance of complementary research methods [54, 55], if the application perspective of the effects of long-term sports training is associated with health (in a positive sense, but also with potential threats). The main limitation of these studies is the results of only Polish athletes and they cover only some of the disciplines qualified for either combat sports or team sports (games). There is also an important factor of trainer competence and the quality of key training sessions.

Response time studies are also more related to the second component of the mission of the recently promoted new applied science INNOAGON [56, 49, 57-60], i.e. broadly understood survival. The response time phenomenon is primarily related to broadly understood personal security [61-63], including in the relations 'human – operated devices – social environment – nature'. Moreover, the practice of combat sports

translates directly into self-defence competences, which is a basic element of increasing personal security. It can therefore be seen that a complementary approach to the research results of athletes with various motor preferences opens up a new perspective for interpretation and formulation of recommendations that go beyond the narrow association of results with usefulness in the field of sport.

5. Conclusions

The specific nature of sports training differentiates athletes in various sports in terms of response time. Combat sports athletes demonstrate shorter simple reaction time compared to choice reaction time, in contrast to athletes in team sports. Representatives of combat sports exhibit similar simple and choice reaction times, similar to athletes in team sports. Long-term sports specialization exerts a positive influence on different types of reactions, which can have a beneficial impact on the safe functioning of individuals, including coping effectively with complex daily tasks.

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Authors:

Sadowski Jerzy: https://orcid.org/0000-0002-1751-9613

Cieśliński Igor: https://orcid.org/0000-0001-8672-9334

Gierczuk Dariusz: https://orcid.org/0000-0002-1131-8095

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