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NEUROMOTOR PROCESSING SPEED, AGILITY AND VISUAL REACTION TIME AS DETERMINANTS OF PSYCHOMOTOR AND TECHNICAL-TACTICAL PERFORMANCE IN PANKRATION ATHLETES

ШВИДКІСТЬ НЕЙРОМОТОРНОЇ ОБРОБКИ, СПРИТНІСТЬ ТА ЧАС ВІЗУАЛЬНОЇ РЕАКЦІЇ ЯК ДЕТЕРМІНАНТИ ПСИХОМОТОРНОЇ ТА ТЕХНІКО-ТАКТИЧНОЇ ПІДГОТОВЛЕНОСТІ СПОРТСМЕНІВ У ПАНКРАТІОНІ

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Abstracts

Background and Study Aim. Pankration is a complex combat sport that requires the integration of multiple psychomotor and cognitive skills. These ones include rapid decision-making, coordination and precise motor execution. The aim of this study was to examine the relationships between neuromotor processing speed, agility and lower-limb visual reaction time. It also intended to determine the contribution of these elements to psychomotor and technical-tactical performance in competitive Pankration athletes.

Material and methods. Sixteen experienced male elite Pankration athletes (mean age 27.63 years), of national and international level, participated in the study. They had a systematic training program, with 4–5 weekly sessions. Agility and neuromotor processing speed were assessed using the Witty system through a computerized agility task (difficulty level 4). Thus, the total completion time, impulse times, number of impulses and consistency indices were measured. Lower-limb visual reaction time was evaluated with the OptoJump system, recording response times for left and right leg across three trials. Technical-tactical performance was assessed in both training (Kato and Agon-Imiepafis exercises) and competition, based on execution quality, tactical adaptation and official scores. Data were analyzed using descriptive statistics and Pearson correlation coefficients to investigate associations between psychomotor and technical-tactical parameters ($p < 0.05$).

Results. Descriptive analysis indicated a relatively stable performance profile. So, the total agility time averaged 26.93 s (CV = 8.40%) and mean lower-limb reaction times were 0.501–0.507 s. Agility showed a significant negative correlation with total Kato scores in training ($r = –0.589$, $p = 0.016$). This fact suggests that faster directional changes enhance technical-tactical performance. Neuromotor processing speed and visual reaction time exhibited selective, weaker correlations, acting as complementary factors in specific action phases. Technical-tactical performance was more consistent in Agon-Imiepafis exercises and competitions than in isolated drills.

Conclusions. Agility proved to be the most consistent psychomotor determinant of technical-tactical performance in Pankration athletes. Neuromotor processing speed and lower-limb visual reaction time contributed selectively. These findings highlight the importance of integrated training programs. Such programs combine agility development, rapid neural processing and visual reaction exercises to optimize performance in combat sports.

Keywords: psychomotor skills, visual reaction, technical-tactical performance, combat sports, training adaptation.

Вступ і мета дослідження. Панкратіон – це комплексний вид одноборств, який вимагає інтеграції декількох психомоторних і когнітивних навичок. До них належать швидке прийняття рішень, координація та точне виконання рухових дій. **Метою** цього дослідження було вивчення взаємозв'язків між швидкістю нейромоторної обробки, спритністю та часом зорово-моторної реакції нижніх кінцівок. Також планувалося визначити внесок цих елементів у психомоторну та техніко-тактичну підготовленість кваліфікованих спортсменів, які займаються панкратіоном.

Матеріал і методи. У дослідженні брали участь шістнадцять досвідчених спортсменів-чоловіків (середній вік 27,63 року), які є елітними атлетами національного та міжнародного рівнів. Вони мали систематичну програму

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тренувань із 4–5 заняттями на тиждень. Спритність і швидкість нейромоторної обробки оцінювали за допомогою системи Witty під час виконання комп'ютеризованого завдання на спритність (рівень складності 4). Таким чином, вимірювали загальний час виконання, час імпульсу, кількість імпульсів та індекси стабільності. Час зорово-моторної реакції нижніх кінцівок оцінювали за допомогою системи OptoJump, реєструючи час реакції для лівої та правої ноги у трьох спробах. Техніко-тактичну результативність оцінювали як у тренувальному процесі (вправи «Като» та «Агон-Іміепафіс»), так і під час змагань, спираючись на якість виконання, тактичну адаптацію та офіційні протоколи. Дані аналізували за допомогою описової статистики та коефіцієнтів кореляції Пірсона для вивчення зв'язків між психомоторними та техніко-тактичними параметрами ($p < 0,05$).

Результати. Описовий аналіз вказав на відносно стабільний профіль результативності. Так, загальний час тесту на спритність становив у середньому 26,93 с (CV = 8,40%), а середній час реакції нижніх кінцівок – 0,501–0,507 с. Спритність продемонструвала значущу негативну кореляцію із загальними балами у вправах «Като» під час тренувань ($r = –0,589$, $p = 0,016$). Цей факт свідчить про те, що швидша зміна напрямку руху підвищує техніко-тактичну результативність. Швидкість нейромоторної обробки та час зорової реакції виявили вибіркові, слабші кореляції, виступаючи як додаткові фактори в специфічних фазах дій. Техніко-тактична результативність була стабільнішою у вправах «Агон-Іміепафіс» та на змаганнях, ніж в ізольованих тренувальних вправах.

Висновки. Спритність виявилася найбільш стабільним психомоторним детермінантом техніко-тактичної результативності спортсменів у панкратіоні. Швидкість нейромоторної обробки та час зорової реакції нижніх кінцівок робили вибірковий внесок. Ці результати підкреслюють важливість інтегрованих програм тренувань. Такі програми повинні поєднувати розвиток спритності, швидку нейронну обробку та вправи на зорову реакцію для оптимізації результатів у бойових мистецтвах.

Ключові слова: психомоторні навички, зорова реакція, техніко-тактична результативність, бойові мистецтва, тренувальна адаптація.

Introduction. Performance in martial arts is determined by the efficient integration of perceptual, cognitive and motor processes. Thus, athletes are enabled to respond rapidly and accurately to continuously changing combat situations. Expert combat sport athletes demonstrate advanced perceptual-motor skills. These ones include faster visual processing and superior anticipatory abilities, compared to non-athletes and those from other sport disciplines [4]. During a fight, athletes must detect visual cues, process sensory information, anticipate opponents' actions and execute coordinated motor responses within extremely short time intervals. Such demands have been shown to differentiate elite from less experienced martial artists, particularly in reaction time and decision-making tasks [31]. These complex demands extend beyond technical-tactical proficiency. They require well-developed psychomotor capacities, as agility, reaction time, postural control and neuromotor efficiency, which together contribute to overall combat performance. Reliable sport-specific reaction time assessments, such as the Striking Reaction Time Task (SRTT), revealed that higher complexity perceptual-motor tasks result in longer reaction times. This finding underlines the importance of perceptual processing in combat sports performance [11]. Consequently, identifying the neurophysiological and motor determinants that underpin performance has become an important focus of contemporary research on sports. It has considerable implications for targeted training and performance optimization in martial arts athletes [30].

Among the key determinants of performance in combat sports, agility represents a central factor for functional efficiency. Traditionally conceptualized as the ability to change direction quickly, agility is now understood as a multidimensional construct. This one encompasses neuromuscular coordination, muscular strength, postural control, sensorimotor integration and rapid decision-making [13, 26, 38]. In combat contexts, athletes are required to execute actions under high temporal constraints and respond to unpredictable stimuli. This necessitates the seamless integration of perceptual, cognitive, and motor processes [14, 38]. Superior agility allows athletes to reposition effectively, evade attacks and exploit tactical opportunities, thereby enhancing both offensive and defensive technical-tactical performance [4, 13, 26]. Moreover, evidence indicates that agility is closely linked with visual reaction time, neuromotor processing speed and cognitive processing abilities. It means that comprehensive training programs targeting these components can optimize combat sport performance [14, 19, 38]. These findings underscore the importance of integrated approaches combining physical conditioning with perceptual-cognitive and sensorimotor training to meet the martial arts competition complex demands.

Another essential factor contributing to performance is neuromotor processing speed. It refers to the rapid transmission, integration and transformation of sensory information within the central nervous system into appropriate motor outputs. Faster neural processing enhances reaction time, anticipatory abilities and movement precision, facilitating more efficient execution of complex motor tasks. Research using transcranial magnetic stimulation (TMS) has demonstrated that corticospinal excitability rises in the interval preceding voluntary movement onset. This rise is closely linked with reaction time performance, reflecting preparatory motor system engagement in response to external stimuli [3, 18]. The TMS studies also show that sport training is associated with specific adaptations in cortical excitability. Properly trained athletes exhibit lower resting motor thresholds, shorter motor-evoked potential latencies and higher excitability compared to non-athletes. This suggests enhanced corticospinal system responsiveness through long-term sports practicing [22]. Besides, studies on Taekwondo and other combat sports point out that martial arts training may improve neuromotor responsiveness and sport-specific reaction time. This is done through improved sensorimotor integration and corticospinal adaptation [7, 29].

Nevertheless, despite its acknowledged importance, neuromotor processing speed remains insufficiently investigated using objective and performance-based indicators in sports. Further applied research is needed in this domain.

Visual reaction time, especially at the lower limbs level, constitutes a critical component of psychomotor efficiency in combat disciplines. Many technical actions, including stepping, dodging, kicking and rapid changes of stance, depend on immediate lower-limb responses to visual stimuli. Even minimal delays in reaction potentially compromise tactical effectiveness and competitive outcomes [26, 28]. Research on combat sports athletes has shown that visuomotor reaction time differs according to performance level. Higher-level competitors demonstrate faster choice reaction times in computerized assessments [28]. Additionally, studies in other athletic populations highlight significant correlations between visual reaction time and agility, suggesting that faster stimulus processing enhances change-of-direction performance [10, 27]. Structured sport training was also linked to neuromotor adaptations, including enhanced corticospinal excitability and improved reaction performance in trained fighters relative to non-athletes [6]. Lower-limb visual reaction time and its relationship with agility and broader psychomotor performance remain underexplored in the literature, particularly in integrated analyses within combat sports like Pankration. This underscores the need for studies that examine these components jointly to better understand their contribution to technical–tactical effectiveness in both training and competition contexts.

Pankration, a full-contact martial art that combines striking, grappling and ground-fighting techniques, imposes high neuromotor, cognitive, and technical–tactical demands. Athletes must continuously adapt their strategies, coordinate rapid transitions between movement patterns and maintain precision under both physical and psychological pressure [25]. This complex performance environment makes Pankration an appropriate model for examining the interaction between neuromotor processing, agility and reaction capabilities. Studies in other combat sports have shown that neuromotor and cognitive training can enhance decision-making, reaction time and sport-specific performance outcomes [35, 36]. However, few studies have provided an integrated analysis of these psychomotor components within the same athletic population. The combined contribution of these components to technical–tactical effectiveness in both training and competition contexts was insufficiently investigated. This fact reveals a clear gap in the current literature.

Therefore, a comprehensive evaluation of neuromotor processing speed, agility parameters and lower-limb visual reaction time is very important. It may provide valuable insights into the mechanisms underlying psychomotor efficiency and its transfer to sport-specific performance. Such knowledge may support the development of evidence-based training strategies to optimize both motor capacities and technical–tactical execution in martial arts athletes.

The *aim of this study* was to examine the relationships between neuromotor processing speed, agility and lower-limb visual reaction time. It also intended to determine the contribution of these ones to psychomotor and technical–tactical performance in competitive Pankration athletes.

Hypotheses of the Study:

(1) athletes with faster neuromotor processing speed would demonstrate superior agility performance;

(2) shorter lower-limb visual reaction times would be associated with better psychomotor control and technical-tactical outcomes; and

(3) these variables would show significant interrelationships, acting as complementary determinants of overall performance in both training and competition.

Materials and methods

Participants

The study included competitive Pankration athletes recruited from affiliated sports clubs participating in national-level training programs. A total of N = 16 male elite athletes voluntarily participated in the investigation. The sample consisted exclusively of male athletes trained in competitive combat sports at national and international level. All of them had systematic training experience of at least three years and a minimum weekly training volume of four to five sessions. The mean age of the participants was 27.63 years. Inclusion criteria were: (a) active participation in organized Pankration training and official competitions; (b) absence of musculoskeletal injuries within the previous three months; (c) no diagnosed neurological or vestibular disorders; and (d) medical clearance for unrestricted physical effort. Exclusion criteria comprised recent injury, acute illness, or failure to complete all testing procedures. Written informed consent was obtained from all participants, as well as from the parents or legal guardians of underage athletes. The study protocol was approved by the Ethics Committee of the Doctoral School of Physical Education and Sport Science, National University of Science and Technology "Politehnica" Bucharest, Pitești University Center (Approval ID: 35/28.03.2025). The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Research design

The research was carried out throughout 2022 and entailed an integrated assessment of technical–tactical preparation during both training and competitive settings from March to November. It was followed by a comprehensive psychomotor testing phase in December to quantify the neuromotor and functional capacities underpinning sport-specific performance in Pankration athletes.

A quantitative, quasi-longitudinal design was employed to examine the relationships between neuromotor processing speed, agility, visual reaction time and psychomotor performance. Testing sessions were conducted under standardized environmental conditions within the training facility to ensure ecological validity and minimize external influences.

The assessment protocol combined laboratory-type objective measurements with sport-specific performance evaluations. This mixed approach allowed both the analysis of fundamental neuromotor capacities and the examination of their transfer to technical–tactical performance in real training and competitive contexts. Methodology was aligned with the pedagogical perspective of sport performance development.

Athletes completed all tests in an established order, with standardized instructions and rest intervals (2–3 minutes) between tasks to reduce fatigue effects.

Instruments and testing procedures. Psychomotor performance components were evaluated using standardized instruments and testing protocols. These ones were provided by the Center for Human Performance Research (CCPU) within the Department of Physical Education and Sport, University Center Pitești, National University of Science and Technology "Politehnica" Bucharest. The use of certified equipment and standardized procedures ensured high measurement accuracy, reliability and reproducibility of the data collected from martial arts athletes. All assessments were performed by specialists, in conformity with institutional testing guidelines, under controlled laboratory conditions.

Agility and neuromotor processing speed assessment

Agility and neuromotor processing speed were evaluated using the Witty system, an intelligent light-based device specifically designed for assessing neuro-motor performance and reaction abilities.

Participants performed a computerized agility task (difficulty level 4) requiring rapid lower-limb responses to randomized visual stimuli. The test involved multiple changes of direction and reactive movements executed under time pressure. The following variables were recorded: total completion time (s), lap/impulse times (L1–L15), number of impulses, mean time per impulse and variability and consistency indices.

These indicators reflect change-of-direction speed, coordination, decision-making efficiency and neural information-processing capacity. From a pedagogical standpoint, the test evaluates the athletes' ability to perceive stimuli, select appropriate motor responses and execute actions quickly. All these skills are essential for combat sports performance.

Visual reaction time assessment

Lower-limb visual-motor reaction time was assessed using the Opto Jump system. This is a digital platform designed for precise measurement of reaction time and biomechanical movement parameters.

The Visual Reaction Speed (VRS) test required participants to respond as quickly as possible to visual stimuli by executing a targeted foot movement. Three trials were performed for each lower limb. The following parameters were recorded: reaction time for the left limb (individual and mean values), reaction time for the right limb (individual and mean values).

This procedure allowed the evaluation of reaction speed, bilateral symmetry, intersegmental coordination and potential neuromuscular imbalances that may influence sport performance or injury risk. The results provide practical information for individualized training interventions aimed at optimizing neuromotor responsiveness.

Technical–tactical performance assessment

Technical-tactical preparation was evaluated using sport-specific assessment tasks conducted in both training and official competition conditions. This was for ensuring ecological validity and relevance to real performance contexts.

During the training phase, athletes engaged in applied combat drills designed to replicate competitive conditions. Each athlete completed three consecutive one-minute bouts against different opponents to simulate repeated high-intensity match demands. Performance was evaluated according to the quality, precision, and effectiveness of the techniques executed, using standardized scoring criteria specific to Kato and Agon-Imiepafis events. This procedure enabled the systematic assessment of technical execution, tactical adaptation, and the ability to maintain performance across repeated efforts.

Technical–tactical performance was assessed independently by two experienced evaluators with expertise in Pankration coaching and competition analysis. Both assessors applied identical standardized criteria to ensure objectivity, consistency, and reliability of the ratings.

In competition, performance was assessed through the official scores obtained in the same events. These measures provided objective evidence of the transfer of technical and tactical skills from training to real competitive situations. They reflected decision-making efficiency and adaptability under pressure.

This combined system supported continuous monitoring of learning outcomes and facilitated targeted pedagogical adjustments within the training process.

Statistical analysis

Data were processed and analyzed using IBM SPSS Statistics (Version 26.0, IBM Corp., USA). Descriptive statistics were calculated for all variables and included: mean, standard deviation (SD), standard error of the mean (SEM), coefficient of variation (CV%), range, skewness, kurtosis, 95% confidence limits of the mean (CLM). Normality of distributions was assessed through skewness and kurtosis indicators and visual inspection of histograms.

Pearson's correlation coefficient (r) was used to examine associations between agility, neuromotor processing speed and visual reaction time parameters. Correlation strength was interpreted as: small ($r < 0.30$), moderate (0.30–0.50) and strong ($r > 0.50$). Statistical significance was set at $p < 0.05$.

Graphical representations of correlation matrices and parameter relationships were generated to facilitate interpretation of inter-variable associations.

Results. The descriptive results obtained for the agility parameters at difficulty level 4 highlight the Pankration athletes' ability to respond effectively to complex motor demands. The results reflect both the specific training characteristics and the neuromotor adaptation level under conditions of intense and variable effort.

Table 1 presents the descriptive results of the agility parameters (difficulty level 4), providing a detailed overview of the Pankration athletes' performance. The mean total time recorded for the test was 26.93 seconds. The moderate variability (CV = 8.40%) reflected a relatively homogeneous group in terms of task execution capacity. The time distribution was slightly negatively skewed (skewness = −0.36). The kurtosis value suggested a relatively flat distribution, indicative of a balanced dispersion of results.

Table 1

Descriptive statistics of agility performance parameters (Difficulty level 4)

Parameters	mean	SEM	SD	CV (%)	Skewness	Kurtosis	CLM (0.95)
Times (sec)	26.93	0.63	2.26	8.40	-0.36	-0.84	1.37
Lap L1	1.807	0.09	0.36	19.86	0.62	0.05	0.22
Lap L2	1.802	0.13	0.48	26.60	1.24	0.71	0.29
Lap L3	1.834	0.06	0.24	12.97	0.45	-0.49	0.14
Lap L4	1.773	0.12	0.45	25.56	1.31	1.35	0.27
Lap L5	1.630	0.04	0.15	9.51	-0.11	-0.77	0.09
Lap L6	1.814	0.06	0.23	12.46	0.31	-0.26	0.14
Lap L7	1.759	0.10	0.37	20.89	1.10	0.29	0.22
Lap L8	2.064	0.17	0.62	30.10	1.16	0.20	0.38
Lap L9	1.694	0.09	0.33	19.30	0.31	-0.69	0.20
Lap L10	1.671	0.06	0.23	13.88	0.00	-1.18	0.14
Lap L11	1.751	0.06	0.23	13.21	-1.09	0.40	0.14
Lap L12	1.914	0.10	0.36	18.97	0.43	-1.12	0.22
Lap L13	1.793	0.10	0.38	21.29	0.97	0.89	0.23
Lap L14	1.842	0.14	0.49	27.09	1.55	1.70	0.30
Lap L15	1.779	0.11	0.41	22.96	0.51	-0.60	0.25

Notes: Lap – impulse; standard deviation (SD); standard error of the mean (SEM); coefficient of variation (CV%); 95% confidence limits of the mean (CLM).

Table 2

Descriptive statistics of neuromotor processing speed parameters during the agility task

Parameters	mean	SEM	SD	CV (%)	Skewness	Kurtosis	CLM (0.95)
Impulses no.	29.38	0.47	1.71	5.82	0.62	-0.48	1.03
Time (sec)	19.57	0.06	0.21	1.09	-1.53	2.26	0.13
Avg. time/impulse (sec)	0.67	0.01	0.03	5.15	-0.60	-1.50	0.02

Notes: standard deviation (SD); standard error of the mean (SEM); coefficient of variation (CV%); 95% confidence limits of the mean (CLM).

Table 3

Descriptive statistics of lower-limb visual reaction time parameters

Segment	mean	SEM	SD	CV (%)	Skewness	Kurtosis	CLM (0.95)
Right foot (s)	0.507	0.01	0.05	9.35	0.31	-0.83	0.03
Left foot (s)	0.501	0.01	0.04	8.60	1.78	3.18	0.03

Notes: standard deviation (SD); standard error of the mean (SEM); coefficient of variation (CV%); 95% confidence limits of the mean (CLM).

A detailed analysis of the impulses (Lap L1–L15) pointed out greater variability across segments, with coefficients of variation ranging from approximately 9.5% (Lap L5) to 30.1% (Lap L8). This difference indicates greater consistency during certain phases of the test. It also highlights increased difficulty in segments such as Lap L8, where the elevated variability (CV = 30.10%) reveals higher motor demands or greater task complexity. Skewness values for the impulses generally showed slight positive asymmetry, more pronounced in Lap L2 (1.24), Lap L4 (1.31), and Lap L14 (1.55). This indicates the presence of extreme values toward longer execution times in these segments. Furthermore, the positive kurtosis observed in Lap L4 and Lap L14 confirms a tendency toward more peaked distributions. It may be associated with individual differences in motor control and adaptive capacity under increased test demands.

Table 2 shows the descriptive results of the neuromotor processing speed parameters associated with agility, including the number of impulses, total processing time (seconds) and mean time per impulse (seconds). The mean number of impulses recorded was 29.38, with low variability (CV = 5.82%), indicating high consistency in impulse frequency across the group. The distribution of this parameter exhibited slight positive skewness (skewness = 0.62), suggesting a predominance of values slightly above the mean. Meanwhile the mildly negative kurtosis (−0.48) revealed a relatively flat distribution without significant extreme values.

The mean total neuromotor processing time was 19.57 seconds, with very low variability (CV = 1.09%), reflecting a uniform level of performance among participants. This measure demonstrated pronounced negative skewness (skewness = −1.53) and positive kurtosis (2.26). It denoted a concentration of data around a central value, with a tendency toward shorter processing times. The mean time per impulse was 0.67 seconds, with moderate variability (CV = 5.15%). Negative skewness (−0.60) and negative kurtosis (−1.50) underline a slightly elongated distribution toward lower values, indicating relatively consistent efficiency in processing time per impulse.

Table 3 presents the descriptive results of lower-limb visual reaction parameters in martial arts athletes. The mean response times for the right and left leg, as well as the variability and symmetry of the data distribution are highlighted. These measures are essential for evaluating motor reaction speed and optimizing performance in complex combat tasks.

The mean visual reaction time for the right leg was 0.507 seconds, with moderate variability as indicated by a coefficient of variation of 9.35%. The data distribution was approximately symmetric, showing slight positive skewness (skewness = 0.31) and negative kurtosis (−0.83). This reflects a slightly platykurtic distribution, i.e., a flatter peak compared to a normal distribution. For the left leg, the mean reaction time was similar, slightly faster at 0.501 seconds, with somewhat lower variability (CV = 8.60%). The data exhibited more pronounced positive skewness (skewness = 1.78) and high positive kurtosis (3.18), indicative of a leptokurtic distribution. It is characterized by a sharper peak and greater concentration of values around the mean, along with the presence of extreme values (outliers). The 95% confidence intervals (CLM 0.95) were identical for both limbs (±0.03 seconds), proving a precise estimation of the mean.

Overall, the psychomotor results confirm a balanced performance profile, with clear potential for optimization through specific training interventions. These ones are aimed at reducing variability in motor actions and improving the consistency of neuromotor responses.

Technical-tactical training is the foundation for effective adaptation to the competition specific demands and is essential for performance in contact sports. In this context, athletes' technical and tactical skills were assessed through simulated matches under competitive conditions. There were included the Kato exercise and Agon-Imiepafis bouts, in which each athlete faced three opponents for one minute each. Performance was measured based on the points scored for executed techniques. The direct correlation between technical-tactical training and the efficiency of its application in competitive situations was pointed out.

Table 4 presents the descriptive analysis of technical–tactical training parameters, reflected in the scores obtained during the Kato exercise and Agon-Imiepafis bouts. It highlights greater consistency and higher level of technique application under realistic competitive conditions compared with isolated execution of individual technical exercises. In the Kato exercise, mean scores per bout ranged from 1.63 to 1.75, with high coefficients of variation (64–90%). This demonstrates substantial dispersion in execution, while the total score averaged 5.06 with moderate variability (CV = 20.99%). In contrast, during the Agon-Imiepafis bouts, mean scores per bout were higher (2.56–2.81) and more consistent (CV ≈ 24–27%). The total score reached a mean of 8.00, with superior consistency (CV = 10.21%). The distributions of scores exhibited slight deviations from symmetry and variability in kurtosis. However, these values remained within acceptable limits, proving a more efficient application of technical-tactical preparation in real combat situations.

Athletes' performance levels were further assessed through the analysis of competition results. Thus, a clear depiction of the efficiency and applicability of techniques under authentic competitive conditions was provided.

Table 4

Descriptive statistics of technical–tactical performance parameters in training by fighting style

Fighting style	Parameters	mean	SEM	SD	CV (%)	Skewness	Kurtosis	CLM (0.95)
Kato	L1 (points)	1.69	0.28	1.14	67.46	-0.20	-0.29	0.61
	L2 (points)	1.75	0.28	1.13	64.31	-0.65	-0.90	0.60
	L3 (points)	1.63	0.36	1.45	89.53	0.15	-1.21	0.78
	Total (points)	5.06	0.27	1.06	20.99	-0.13	-0.71	0.57
Agon-Imiepafis	L1 (points)	2.56	0.16	0.63	24.55	0.59	-0.58	0.34
	L2 (points)	2.81	0.19	0.75	26.67	0.30	-1.07	0.40
	L3 (points)	2.63	0.18	0.72	27.38	0.66	-0.74	0.38
	Total (points)	8.00	0.20	0.82	10.21	0.76	0.52	0.44

Notes: L – partner sparring bout (1 min); standard deviation (SD); standard error of the mean (SEM); coefficient of variation (CV%); 95% confidence limits of the mean (CLM).

Table 5

Descriptive statistics of technical–tactical performance parameters in competition by fighting style

Fighting style	Parameters	mean	SEM	SD	CV (%)	Skewness	Kurtosis	CLM (0.95)
Kato	Match duration (min)	4.69	0.12	0.48	10.21	-0.81	-1.35	0.26
	Total score (points)	5.44	0.50	2.00	36.76	0.92	0.09	1.07
Agon-Imiepafis	Total score (points)	7.93	0.68	2.63	33.17	-0.07	-0.83	1.46

Notes: standard deviation (SD); standard error of the mean (SEM); coefficient of variation (CV%); 95% confidence limits of the mean (CLM).

Table 6

Relationship between psychomotor variables and technical–tactical performance measures

Parameters r; P	Psychomotor parameters (PM)					
	PM1	PM2.1	PM2.2	PM2.3	PM3.1	PM3.2
x1	.038; 0.889	.150; 0.579	.242; 0.367	-.039; 0.886	-.036; 0.896	-.272; 0.309
x2	.073; 0.788	.271; 0.311	.349; 0.185	-.280; 0.294	-.421; 0.105	.480; 0.060
x3	-.176; 0.515	-.328; 0.215	-.185; 0.494	.323; 0.222	.571*; 0.021	-.434; 0.093
x4	-.123; 0.651	-.002; 0.995	.376; 0.152	.104; 0.701	.298; 0.262	-.377; 0.150
x5	-.589*; 0.016	-.239; 0.372	.013; 0.961	.246; 0.359	.419; 0.106	-.279; 0.295
x6	.255; 0.340	-.102; 0.708	.224; 0.405	.127; 0.638	-.279; 0.296	.305; 0.250
x7	-.074; 0.785	-.014; 0.959	-.126; 0.642	-.092; 0.735	.001; 0.998	-.064; 0.813
x8	-.284; 0.286	-.265; 0.321	.105; 0.699	.225; 0.401	.068; 0.803	.009; 0.974
x9	-.123; 0.649	-.087; 0.748	.062; 0.818	.046; 0.866	.160; 0.554	.287; 0.280
x10	-.178; 0.526	-.085; 0.764	.041; 0.885	.092; 0.746	.007; 0.981	-.482; 0.068

Notes: r – Pearson correlation coefficient; p – significance level; x1–x4: technical–tactical performance (Kato style) in training (1 – L1, 2 – L2, 3 – L3, 4 – Total score). x5–x8: technical–tactical performance (Agon-Imiepafis style) in training (L1–L3, Total score). x9: Kato performance in competition; x10: Agon-Imiepafis performance in competition; PM1 – psychomotor factor (agility, difficulty level 4 – total time); PM2 – neural processing speed during agility (2.1 – number of impulses, 2.2 – total time, 2.3 – mean impulse time); PM3 – visual reaction time (3.1 – left foot, 3.2 – right foot). Significant correlations are marked with ($p < .05$).

The analysis of technical-tactical performance in competition, shown in Table 5, emphasized a mean match duration of 4.69 minutes. The coefficient of variation was 10.21%, indicating a high level of homogeneity and stability in match duration. Technical–tactical performance in the Kato exercise averaged 5.44 points, with relatively high variability (CV = 36.76%), reflecting significant individual differences among athletes. In the Agon-Imiepafis bouts, the mean total score was 7.93 points, with moderate variability (CV = 33.17%). This points out a more consistent performance, still with notable differences between competitors. Skewness and kurtosis values suggest a slightly heterogeneous distribution of results, revealing the presence of variability in technical-tactical performance during competitive conditions.

Pearson correlation analysis was conducted to examine the relationships between psychomotor parameters and technical-tactical performance in both training and competition (Table 6). The psychomotor parameters involved were agility, neuromotor processing speed and lower-limb visual reaction time.

Agility (PM4) demonstrated a significant negative correlation with the total Kato score in training (x5; r = –0.589, p = 0.016). It shows that faster execution in the agility task was associated with higher technical–tactical performance. This finding underscores the importance of rapid change-of-direction ability and movement efficiency for the effective application of techniques in simulated combat scenarios.

Neuromotor processing speed (PM2) had weak and non-significant correlations with technical–tactical outcomes ($p > 0.05$). It indicates a supportive, but not primary, role of neuronal processing efficiency in determining performance under the tested conditions.

Lower-limb visual reaction time (PM3) revealed selective associations with technical-tactical indicators. A moderate positive correlation was observed between left-leg reaction time and the L3 (partner sparring bout) Kato score in training (x3; r = 0.571, p = 0.021). Meanwhile a trend toward a negative association emerged between right-leg reaction time and Agon performance in competition (x10; r = –0.482, p = 0.068). These results suggest that lower-limb reaction speed can contribute to performance in specific phases of combat, although the relationships are task-dependent.

Generally, most psychomotor parameters exhibited weak linear associations with technical-tactical outcomes, reflecting the multifactorial nature of performance in Pankration. Agility has been shown as the most consistent psychomotor determinant. As for the neuromotor processing speed and visual reaction time, they appear to play complementary roles, contingent on the performance context.

Discussion. Analyzing the results obtained in this study provides important insights into the role of psychomotor parameters in determining technical-tactical performance in Pankration athletes.

Firstly, the descriptive results for agility (difficulty level 4) indicate that the athletes were able to respond rapidly and efficiently to complex motor demands. A relatively homogeneous group performance was found out in terms of total execution time. Higher variability observed in certain segments (Lap L8, CV = 30.10%) suggests zones of increased difficulty. In these zones, the cognitive and motor demands were higher, reflecting the inherent challenges of rapid information processing and direction changes under pressure. These findings highlight the importance of agility not only as a physical skill but also as an indicator of the efficiency of coordination and motor adaptation processes in dynamic tasks.

The results are consistent with previous specialized literature, which emphasizes the impact of expertise level on postural control in combat sports practitioners [1]. Moreover, movement variability is considered a functional mechanism essential for supporting performance in complex actions, such as striking tasks characteristic of contact sports [24]. Therefore, it is necessary to develop targeted training programs to enhance agility and dynamic stability.

Overall, the findings underline a well-developed general agility, with stable performance throughout the test, but with specific segments showing greater variability. Opportunities to optimize reaction capacity and rapid change-of-direction ability at key moments are identified.

Neuromotor processing speed parameters demonstrated high consistency among participants, reflecting that Pankration athletes present uniform efficiency in generating rapid motor impulses. Although correlations with technical-tactical performance were weak and non-significant, these results suggest that neuromotor processing speed may play a supportive role. It assists agility and visual reaction, without serving as a primary predictor of performance scores. Thus, in complex combat situations, technical–tactical performance depends mainly on integrating multiple psychomotor and cognitive components, rather than solely on raw impulse processing speed.

Recent studies emphasize point out that neural processing speed and reaction time are critical for martial arts performance, influencing both the specific techniques execution and general agility. Neuromuscular stimulation interventions and training targeting the corticospinal system can reduce reaction time and improve movement precision. This fact emphasizes the importance of integrating cognitive and motor aspects into training programs [5, 20, 23]. The information above confirms that optimizing neural impulses is essential for the development of neuromotor performance in elite athletes.

Data reflect stable and efficient neuromotor processing, characterized by a consistent number of impulses and well-defined processing duration. This reveals uniform neuromotor performance across the analyzed athletes.

The results concerning lower-limb visual reaction time pointed out selective associations with technical-tactical performance. There is a positive correlation between the reaction time of the left leg and the L3 Kato score. It shows that rapid responses to visual stimuli may facilitate the execution of techniques during the final phases of simulated combat. In contrast, a negative trend is observed between right-leg reaction time and Agon performance in competition. It may reflect the influence of contextual or individual factors on the effective utilization of rapid reactions in real competitive situations. These differences prove that laterality and bilateral control may modulate the impact of reaction speed on technical-tactical performance.

Recent studies highlight that lower-limb visual reaction plays a crucial role in martial arts performance, affecting the efficiency of motor responses in dynamic combat situations. Rapid and precise reaction times allow athletes to select and execute complex movements in a timely manner. This is essential for success in disciplines such as judo, karate or mixed martial arts (MMA) [2, 8, 28]. Furthermore, individual variability in visual responses underscores the need for tailored training programs. These programs must be specifically adapted to the demands of each discipline and the motor profile of the athlete.

In this regard, lower-limb visual reaction time was similar on average for both legs, with a slight temporal advantage for the left leg. Variability was reasonably low, indicating consistency in visuomotor responses. However, the distribution of reaction times for the left leg was more asymmetric and concentrated. This may reflect generally homogeneous performance with some extreme values within the group.

Technical-tactical performance was more consistent and higher during the Agon-Imiepafis bout compared to the Kato exercise. This fact indicates a more effective transfer of skills under actual combat conditions. The lower coefficients of variation observed in Agon (CV total 10–27%) demonstrate that athletes execute techniques more consistently when integrated into a competitive framework. This highlights the importance of contextualized training and competition simulations for the development of integrated performance.

The importance of technical-tactical preparation in contact sports is analyzed in some new works. For example, a study published in 2025 pointed out that training programs incorporating combined attacks enhance athlete performance in MMA. These programs must be correlated with psychophysiological parameters such as simple and complex visuomotor reaction times. Similarly, research from 2023 emphasizes the necessity of sport-specific technical-tactical preparation for MMA athletes in advanced specialization stages to achieve high-level performance. Also, analyzing MMA competition performance demonstrates that the use of various techniques and their adaptation to the opponent's style are key determinants of competitive success [9, 12, 15].

Time-motion analysis in judo provides fundamental insights into the temporal and tactical structure of combat. This analysis enables coaches to optimize training strategies and athletes to enhance performance. This is possible through a detailed understanding of the duration, frequency and sequencing of specific actions, including grips, attacks and transitions between techniques [21, 32, 34]. Such analyses reveal significant differences across weight categories, competitive levels and age groups. Also, the importance of adopting individualized training approaches tailored to the temporal and biomechanical characteristics of each athlete is highlighted.

Assessment of sports performance constitutes an essential tool for optimizing training and monitoring athlete progress in competitive contexts. Research shows that utilizing performance data from competitions enables coaches and researchers to identify strengths and areas requiring improvement. It contributes to more effective training planning and the practical application of technical skills in real scenarios [17, 33, 37]. This approach ensures a direct linkage between theoretical evaluation and practical execution of athletic abilities, increasing the efficiency of strategic interventions. Results obtained by analyzing the technical–tactical parameters in competition confirm that performance variability serves as a key indicator of athlete resilience in real combat situations. This finding is supported by studies analyzing technical variability among elite judo athletes during the Olympic Games [16].

Overall, the correlation analysis confirms the hypothesis that agility represents the strongest psychomotor determinant of technical–tactical performance. Neuromotor processing speed and visual reaction time act as complementary factors, relevant during specific phases of sport actions. This integration of parameters suggests that optimizing performance in Pankration requires complex training programs targeting agility, visual reactions and rapid information-processing capabilities simultaneously.

Conclusions.

1. The results of this study indicate that psychomotor parameters, particularly agility, represent key determinants of technical–tactical performance in Pankration athletes. Agility had a significant correlation with Kato exercise scores during training. It demonstrated that the ability to rapidly change direction and move efficiently contributes to effective application of techniques in simulated combat scenarios.
2. Neuromotor processing speed and lower-limb visual reaction time acted as complementary factors, relevant during specific sport phases. This suggests that optimal performance relies on the simultaneous integration of multiple psychomotor and cognitive components.
3. Descriptive analyses revealed relatively stable performance throughout the tests, with certain segments presenting higher variability. These variations highlight opportunities for optimizing rapid reactions and directional changes during training.
4. In competitive conditions, technical-tactical performance was more consistent and higher during the Agon-Imiepafis combat compared to the Kato exercise. This emphasizes the importance of contextualized simulations for effective transfer of skills to real combat situations.
5. The study confirms the hypothesis that agility is the most consistent and significant psychomotor determinant of technical-tactical performance. Neuromotor processing speed and visual reaction contribute complementarily depending on the type and phase of action. These findings underscore the need for integrated training programs that simultaneously develop agility, enhance rapid neural processing and train specific visual-motor reactions. The purpose is to maximize performance in Pankration and similar combat disciplines.

Limitations of the study and future research

The main limitations of the present study include the relatively small sample size, which may restrict the generalizability of the findings. Also, another limitation is the limited temporal scope of testing, without assessing seasonal or long-term training effects. Additionally, the study focused primarily on psychomotor parameters, namely agility, neuromotor processing speed and lower-limb visual reaction. It did not consider supplementary factors such as fatigue, psychological stress, or cognitive load, which may influence technical-tactical performance.

Future research should address these limitations by including larger and more diverse groups of athletes. It also should implement longitudinal designs that capture the psychomotor parameters evolution and technical-tactical performance across multiple training cycles or competitive seasons. It is recommended to examine the interactions between psychomotor components and contextual competition factors, including stress, fatigue and decision-making demands. The integration of neurocognitive and biomechanical analyses, along with real-time performance monitoring, may provide a more comprehensive understanding of performance determinants. This will support the development of optimized training programs for Pankration athletes and practitioners of other complex martial arts disciplines.

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References

1. Akbaş, A., Marszałek, W., Drozd, S., Czarny, W., Król, P., Warchoł, K., ... & Rzepko, M. (2022). The effect of expertise on postural control in elite sport ju-jitsu athletes. BMC Sports Science, Medicine and Rehabilitation, 14(1), 86. https://doi.org/10.1186/s13102-022-00477-3
2. Bajkowski, D. S., & Cynarski, W. J. (2024). Testing factors influencing handgrip strength and reaction time to visual stimulus in selected martial arts. Journal of Kinesiology and Exercise Sciences, 34(105), 46-59. https://doi.org/10.5604/01.3001.0054.3260
3. Chen, R., Yaseen, Z., Cohen, L. G., & Hallett, M. (1998). Time course of corticospinal excitability in reaction time and self-paced movements. Ann Neurol, 44(3),317–25. https://doi.org/10.1002/ana.410440306
4. Chen, W. Y., Wu, S. K., Song, T. F., Chou, K. M., Wang, K. Y., Chang, Y. C., & Goodbourn, P. T. (2017). Perceptual and motor performance of combat-sport athletes differs according to specific demands of the discipline. Perceptual and motor skills,124(1),293-313. https://doi.org/10.1177/0031512516681342
5. Chmiel, J., & Nadobnik, J. (2025). Application of Electroencephalography (EEG) in Combat Sports – Review of Findings, Perspectives, and Limitations. Journal of Clinical Medicine, 14(12), 4113. https://doi.org/10.3390/jcm14124113
6. Chung, P. Y. M. (2012). Neuromotor control in Taekwondo practitioners of different training levels. (Doctoral dissertation). Hong Kong Polytechnic University – Dissertations.
7. Chung, P., & Ng, G. (2012). Taekwondo training improves the neuromotor excitability and reaction of large and small muscles. Physical Therapy in Sport, 13(3),163-169. https://doi.org/10.1016/j.ptsp.2011.07.003
8. Cojocariu, A., & Abalasei, B. (2014). Does the reaction time to visual stimuli contribute to performance in judo. Archives of Budo, 10(1), 73-78.
9. Davidenko, I., Kazymov, M., Akmatova, A., Bolotin, A., Pronin, E., Anisimov, M., ... & Volkov, A. (2025). Effects of combined attacks on the technical-tactical and psychophysiological performance of mixed martial arts fighters. Journal of Physical Education and Sport, 25(6), 1166-1172. https://doi.org/10.7752/jpes.2025.06129
10. Demir, O., & Kıyıcı, F. (2023). Investigation of the relationship of cognitive performance, visual reaction time and agility parameters on football players. SPORMETRE Beden Eğitimi Ve Spor Bilimleri Dergisi, 21(3), 107-116. https://doi.org/10.33689/spormetre.1255170
11. Faro, H., Lima, L. A. D. D., Silva, R. D. M. D., Mortatti, A. L., & Machado, D. G. D. S. M. (2025). Development and reliability of test to measure perceptual-motor performance in combat sports: the Striking Reaction Time Task (SRTT). Revista de Artes Marciales Asiáticas, 20(1),77-92. https://doi.org/10.18002/rama.v20i1.2505
12. Gheorghiu, I. (2023). Technical–tactical training methods applied in the training process of mixed martial arts fighters. Journal of Physical Education and Sport, 2259-2265. https://doi.org/10.7752/jpes.2023.08259
13. Gumienna, R., Machowska-Krupa, W., & Kosendiak, J. (2024). Speed of performing complex movement tasks under decision-making conditions as a determinant of the tactical preparation level in kickboxers. Scientific reports, 14(1), 3002. https://doi.org/10.1038/s41598-024-53652-6
14. Homsombat, T., & Ngambang, J. (2024). Enhancing Cognitive Processing Speed Through Two-Handed Sword Training in Thai Healthy University Students: A Pre-Experimental Study. Journal of Health Science and Alternative Medicine, 12(2),112–120.
15. Ismatullayeva, S. R. (2024). Fundamentals of increasing the efficiency of competition activity and developing technical and tactical training. Mental Enlightenment Scientific-Methodological Journal, 5(06), 76-85. https://doi.org/10.37547/mesmj-V5-I6-10
16. Kons, R. L., Agostinho, M. F., Santos, D. F. C., Lopes-Silva, J., Detanico, D., & Franchini, E. (2022). Match-related performance during the Olympic Games 2020: a technical variability analysis of high-level judo athletes. International Journal of Performance Analysis

in Sport, 22(4), 516-525. https://doi.org/10.1080/24748668.2022.2084594
17. Koopmann, T., Faber, I., Baker, J., & Schorer, J. (2020). Assessing technical skills in talented youth athletes: a systematic review. Sports Medicine, 50(9), 1593-1611. https://doi.org/10.1007/s40279-020-01299-4
18. Leocani, L., Cohen, L. G., Wassermann, E. M., Ikoma, K., & Hallett, M. (2000). Human corticospinal excitability evaluated with transcranial magnetic stimulation during different reaction time paradigms. Brain, 123(6), 1161-1173. https://doi.org/10.1093/brain/123.6.1161
19. Limani, N., & Bulica, B. (2024). Insights into contemporary dynamics of combat sports: a holistic analysis. Sport and Health-International Journal of Sport Sciences and Health, 11(23-24), 61-71. http://eprints.unite.edu.mk/id/eprint/1620
20. Makronasios, N. S., Amiridis, I. G., Evaggelos, B., Theodoros, K. M., Plastraki, A. C., Sahinis, C., & Enoka, R. M. (2024). Neuromuscular electrical stimulation improves reaction time and execution time of roundhouse kick in highly skilled martial arts athletes. Sports Biomechanics, 23(12), 3370-3381. https://doi.org/10.1080/14763141.2023.2216186
21. Miarka, B., Del Vecchio, F. B., Julianetti, R., Cury, R., Camey, S., & Franchini, E. (2016). Time-motion and tactical analysis of Olympic judo fighters. International Journal of Performance Analysis in Sport, 16(1), 133-142. https://doi.org/10.1080/24748668.2016.11868876
22. Monda, V., Valenzano, A., Moscatelli, F., Salerno, M., Sessa, F., Triggiani, A. I., ... & Messina, A. (2017). Primary motor cortex excitability in karate athletes: a transcranial magnetic stimulation study. Frontiers in physiology, 8, 695. https://doi.org/10.3389/fphys.2017.00695
23. Moscatelli, F., Messina, G., Valenzano, A., Petito, A., Triggiani, A. I., Messina, A., ... & Cibelli, G. (2016). Differences in corticospinal system activity and reaction response between karate athletes and non-athletes. Neurological sciences, 37(12), 1947-1953. https://doi.org/10.1007/s10072-016-2693-8
24. Orth, D., van der Kamp, J., & Rein, R. (2018). Optimization as adaptability: How movement variability supports performance in striking actions used in combat sports. Sport Science: current and future trends for performance optimization, 295-316.
25. Pawluk, I.C., & Zukow, W. (2011). Humanities dimension of physiotherapy, rehabilitation, nursing and public health. Publishing House: Radom University, Radom, Poland.
26. Platonov, V., & Nikitenko, A. (2019). Agility and coordination testing in hand-to-hand combat sports. Polish Journal of Sport and Tourism, 26(2), 7-13. https://doi.org/10.2478/pjst-2019-0008
27. Popowczak, M., Domaradzki, J., Rokita, A., Zwierko, M., & Zwierko, T. (2020). Predicting visual-motor performance in a reactive agility task from selected demographic, training, anthropometric, and functional variables in adolescents. International Journal of Environmental Research and Public Health, 17(15), 5322. https://doi.org/10.3390/ijerph17155322
28. Predoiu, R., Fronso, S. D., Stănescu, R., Ozarchevici, C., & Cosma, G. (2025). Visuomotor reaction time in combat sports. Timisoara Physical Education & Rehabilitation Journal, 8(34). https://doi.org/10.2478/tperj-2025-0011
29. Rodrigues, G. T., Barela, J. A., Furlanetto, B., Silva, R. J., Sanches, M. A., & Orcioli-Silva, D. (2025). Taekwondo practitioners exhibit faster simple reaction times compared to physically inactive individuals. Brazilian Journal of Motor Behavior, 19(1), e478-e478. https://doi.org/10.20338/bjmb.v19i1.478
30. Romanenko V., Cynarski W. J., Tropin Y., Kovalenko Y., Korobeynikov G., Piatysotska S., Gaziyev S. (2025). Methodology for Assessing Spatial Perception in Martial Arts. Applied Sciences, 15(6):3413. https://doi.org/10.3390/app15063413
31. Russo, G., & Ottoboni, G. (2019). The perceptual-cognitive skills of combat sports athletes: A systematic review. Psychology of Sport and Exercise, 44, 60-78. https://doi.org/10.1016/j.psychsport.2019.05.004
32. Sacripanti, A., & Ahmedov, F. (2021). Judo Combat: Time-Motion Analysis and Biomechanical Approach. The Arts and Sciences of Judo, 1(1), 126-139.
33. Smith, D. J., Norris, S. R., & Hogg, J. M. (2002). Performance evaluation of swimmers: scientific tools. Sports medicine, 32(9), 539-554. https://doi.org/10.2165/00007256-200232090-00001
34. Soriano, D., Irurtia, A., Tarragó, R., Tayot, P., Milà-Villaroel, R., & Iglesias, X. (2019). Time-motion analysis during elite judo combats (defragmenting the gripping time). Archives of Budo, 15, 33-43.
35. Stanley, E. (2020). Maximal punching performance in amateur boxing: An examination of biomechanical and physical performance-related characteristics. (Doctoral dissertation). University of Chester, UK.
36. Tsaklis, P. (2023). Does neuromotor training accelerate football-specific decision making outcomes in professional football players over two seasons? Science Performance and Science Reports, 212(1).
37. Vandenbogaerde, T. J., Hopkins, W. G., & Pyne, D. B. (2012). A competition-based design to assess performance of a squad of elite athletes. Medicine & Science in Sports & Exercise, 44(12), 2423-2427. https://doi.org/10.1249/MSS.0b013e318267c029
38. Zemková, E. (2022). Cognition and motion: Sensory processing and motor skill performance in athletic training and rehabilitation. Applied Sciences, 12(20), 10345. https://doi.org/10.3390/app122010345