

# Mental toughness and physical fitness tests of boxing athletes associated with big five personality factors

## Testes de resistência mental e aptidão física de atletas de boxe associados aos cinco grandes fatores de personalidade

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**Abstract** - The present study related to boxing athletes' mental toughness and physical fitness performances with Big Five Factors. For this, the sample was composed of eleven recreational boxers who competed at the state level and were regularly training (technical and tactical) 4 times a week during the evaluation period. The 44-item Big Five Inventory (BFI) measures the Big Five dimensions of Conscientiousness, Agreeableness, Neuroticism, Openness, and Extraversion and the 14-item Sports Mental Toughness Questionnaire (SMTQ) were applied with Strength, Power, and Endurance Tests, Pearson and Spearman's correlations were used to verify the association between BFI, physical and mental tests, respectively,  $p \leq .05$ . Our results demonstrated that significant and strong correlation between agreeableness factor and sit-ups test, with  $40.85 \pm 12.36$  freq./min ( $r = .72$ ,  $p = .02$ ) and, in SMTQ, a strong correlation between Neuroticism and Control [10(9;12) score,  $r = .76$ ,  $p \leq 0.01$ ], Constancy [10(9;12) score,  $r = .84$ ,  $p \leq 0.01$ ] and Total SMTQ [37(34;37) score,  $r = .84$ ,  $p \leq 0.01$ ]. In conclusion, these results suggest that Neuroticism factors are associated with mental toughness, while the agreeableness factor is related to muscular endurance capability. Mental toughness and endurance results are associated with boxers' personalities whose drive motivates them relentlessly towards success and promotes thriving in boxing training environments or during championships.

**Keywords:** Task performance and analysis; Endurance; Power; Martial arts; Sport psychology.

**Resumo** - O presente estudo relacionou a resistência mental e o desempenho da aptidão física de atletas de boxe com os cinco grandes fatores. Para isso, compuseram o presente estudo onze boxeadores recreativos que competiram em nível estadual e estavam treinando regularmente (técnico e tático) 4 vezes por semana durante o período de avaliação. O Big Five Inventory (BFI) de 44 itens mede as dimensões de Conscienciosidade, Amabilidade, Neuroticismo, Abertura e Extroversão e o Questionário de Resistência Mental Esportiva (SMTQ) de 14 itens foram aplicados com Testes de Força, Potência e Resistência, Pearson e as correlações de Spearman foram utilizadas para verificar a associação entre IMC, testes físicos e mentais, respectivamente,  $p \leq 0.05$ . Nossos resultados demonstraram correlação significativa e forte entre o fator de amabilidade e o teste de abdominais, com  $40,9 \pm 12,4$  freq./min ( $r = 0,72$ ,  $p = 0,02$ ) e, no SMTQ, uma forte correlação entre Neuroticismo e Controle [10 (9;12) pontuação,  $r = 0,76$ ,  $p \leq 0,01$ ], Constância [10(9;12) pontuação,  $r = 0,84$ ,  $p \leq 0,001$ ] e total SMTQ [37(34;37) pontuação,  $r = 0,84$ ,  $p \leq 0,001$ ]. Em conclusão, esses resultados sugerem que os fatores de neuroticismo estão associados à resistência mental, enquanto o fator de amabilidade está associado à capacidade de resistência muscular. Os resultados de resistência mental e resistência estão associados à personalidade dos boxeadores, cuja motivação os impulsiona implacavelmente para o sucesso e promove o sucesso em ambientes de treinamento de boxe ou durante campeonatos.

**Palavras-chave:** Desempenho e análise de tarefas; Resistência; Potência; Artes marciais; Psicologia do esporte.

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## INTRODUCTION

Boxing is a high-intensity intermittent striking combat sport characterized by complex skills and tactical key actions with short duration<sup>1</sup>. Power with the integration of responses, coordination, and correct timing is necessary for the useful application of techniques<sup>2</sup>. Tests conducted to verify the performance of specific skills within a structural action similar to boxing techniques, such as the Countermovement jump and Medicine ball throw, have a strong relationship with athletes' practical technical-tactical abilities during simulations<sup>2,3</sup>. Nevertheless, even though previous studies have examined athletes' physiological attributes<sup>3</sup>, little scientific information exists on the psychological demands of its participants, primarily associated with personality.

Mental toughness studies describe athletes' personalities whose drive motivates them relentlessly towards success and promotes thriving in sports combats or training environments<sup>4,5</sup>. However, few investigations in combat sports have observed mental toughness, which affects performance outcomes<sup>4</sup>, or in developing relevant motor units and increasing the efficiency of different muscular movements in specific tests<sup>6,7</sup>. Despite conceptual variations, most studies involve anxiety, emotional control, and mood states<sup>8-10</sup>. For clarity and consensus, quantitative research is required to support the hypothesized issues underlying mental toughness, especially concerning key qualities across striking combat domains<sup>6</sup>.

Research in the area outlines mental toughness as a hierarchical construction, and several conceptual models have been proposed in striking combat<sup>4,8</sup>. The SMTQ consists of three mental toughness factors (control, constancy, and confidence), combined into an overall mental toughness score<sup>4,11</sup>. Research into the relationship between mental toughness and performance has consistently shown that better physical fitness performance is associated with higher levels of mental toughness in kickboxers<sup>4</sup>. Some studies compare physical and mental factors between different personalities have reported significant differences between kickboxers<sup>6,12</sup>.

The Big Five personality factors demonstrate aspects of personality trait assessments independent of culture and language and deliver a common framework. The personality analysis helps to understand dissimilar and diverse personality systems in combat and team sports<sup>13</sup>. They represent personality at the broadest level of abstraction in which each measurement delivers a quantity of more distinct personality features<sup>14</sup>. The markers provided for the five personality dimensions are simple, so a brief description of each factor could help coaches and psychologists improve athletes' mental strategies.

Neuroticism contrasts emotional constancy with negative affectivity and contains traits like experiencing negative emotional states, generating irrational ideas, and being impulsive and self-conscious<sup>15</sup>. Extraversion suggests an energetic approach towards the social and material world; athletes with extraversion personality present a tendency to experience positive emotions, be outgoing, cheerful, active, and self-assured<sup>16</sup>. Agreeableness distinguishes a prosocial and communal orientation towards others with antagonism and is connected with being unselfish, compliant, trusting, modest, and helpful<sup>13,14</sup>. Conscientiousness is socially associated with impulse control and assists task- and goal-directed behaviors<sup>13</sup>. It contains such features as being purposeful in cognition and behavior, organized, following rules and norms, strong-mindedness, delaying

gratification, and being self-disciplined<sup>14</sup>. Lastly, Openness to Experience refers to inventiveness, extensiveness, and complexity of an individual's mental and experiential life<sup>17</sup>. Openness includes traits such as being curious, creative, having unconventional values, and having a flexible way of thinking<sup>13</sup>. Personality has been considered a contextual factor that could influence each aspect of the performance process. The Big Five personality dimensions could affect the mental toughness of high-level athletes of team and combat sports<sup>8,13</sup>; however, this is the first time the personality effects are related to mental toughness and physical fitness performance boxing practitioners. Therefore, attempting to extend the previous studies, the present study aims to correlate boxing athletes' mental toughness and physical fitness performances per each of the Big Five Factors.

## METHODS

### Participants

Eleven recreational boxers (age:  $28.5 \pm 6.7$  years-old, height:  $1.8 \pm 0.1$ m, wingspan:  $1.84 \pm 0.4$ m and  $88.1 \pm 13.6$ kg) were selected in a randomized method. All participants had more than ten months of experience. Inclusion criteria: We included complete data of athletes, which showed all the results for each of the tests used in the present study, aged over 18 years, having no cognitive alterations, no recent surgeries, and no injuries, and having more than ten months of practice. Exclusion criteria: fighters who were unable to complete the physical or mental tests, athletes with physical or mental limitations during the study, mainly for health reasons, being duly certified by doctors. The participants were also instructed not to intake alcohol or drugs for at least 24 hours before the measures and were maintaining typical diets. Before the data collection, all participants attended a briefing meeting and signed an informed consent document to ensure their understanding of the testing parameters and the risks and benefits of the study. This study was submitted to and approved by the Local Committee of Ethics in Research (n. 3.722.914), following the National Health Council's rules of resolution and according to the WMA Declaration of Helsinki.

### Procedures

Athletes were familiarized with the test battery during the week before beginning the experiment to avoid the learning effect during the study's testing period. The participants replied to the Big Five and Mental Toughness tests before the physical fitness tests. The questionnaires were distributed by an investigator who explained that the study's purpose was to examine the mental toughness of the subject after each test. The athletes also completed a consent form reflecting the confidential and voluntary nature of their involvement in the study. The investigator was present to clarify doubts. Next, a standard 10-min warm-up, including jogging, dynamic stretching, and jumps, preceded the physical performance testing. Considering the lack of a specific boxing performance test in the literature, we required athletes to perform a non-specific battery of physical performance tests<sup>18</sup>. We based our choice on other studies evaluating combat sports athletes. The validity and feasibility of the tests were also considered<sup>4,18</sup>.

## Measures

The 44-item Big Five Inventory (BFI) measures the Big Five dimensions of Conscientiousness, Agreeableness, Neuroticism, Openness, and Extraversion. BFI used a 5-point rating scale, ranging from 1-strongly disagree to 5-strongly agree. The BFI shows good reliability, retest reliability, factor structure, and convergent and discriminant validity<sup>13</sup>. The reliability for the five factors in the present study was satisfactory (Cronbach's alpha: 0.71 (Openness), 0.77 (Agreeableness), 0.79 (Neuroticism), 0.81 (Conscientiousness), and 0.82 (Extraversion)<sup>15</sup>. For this study, we linearly transformed the raw metric data into a percentage of the maximum possible (POMP); therefore, the scores from the BFI ranged between 0 and 100<sup>16</sup>.

The SMTQ was also used to measure MT. The 14-item SMTQ provides an overall measure of MT and the three subscales of confidence, constancy, and control. Participants respond to items using a 4-point Likert scale ranging from (1), not true to (4) very true. Sample items include "I have unshakeable confidence in my ability" (confidence); "I get distracted easily and lose my concentration" (constancy), and "I get anxious by events I did not expect or cannot control" (control). The SMTQ includes a conceptualization of mental toughness from a positive psychology "mindset" perspective. This questionnaire focuses on an individual's ability to overcome adversity and the attributes that enable them to thrive and grow under all circumstances, including self-belief, commitment, perseverance, and emotional management<sup>5</sup>. Reliability and validity procedures were performed for the SMTQ, with all subscales  $\alpha$ s >0.70 and are significantly inter-correlated<sup>4</sup>.

Abdominal endurance verified muscular resistance, according to the test described by previous authors<sup>19</sup>. The athlete was in the supine position, with their arms crossed and knees flexed, and the athletes did the complete movement<sup>19</sup>. The resistance test of upper limbs is important because it helps fighters to perform defensive actions.

The maximal isometric handgrip (BMS Hydraulic Hand Dynamometer, Brazil) assessment (dominant hand) verified the maximal strength condition. Preceding reports have indicated strong test-retest reliability (Intraclass correlation coefficient - ICC = 0.87)<sup>20,21</sup>. Athletes were instructed to stand with their shoulder adducted; elbow flexed at 90°, and their forearm and wrist in a neutral position. The dynamometer grip was orientated to each athlete's metacarpophalangeal joint. Participants were instructed to maintain a maximal 5s isometric contraction during each attempt. Each athlete performed three maximum trials on each hand, in an alternating manner, with one-minute recovery between attempts. The peak value from each hand was recorded and used for further analysis<sup>20</sup>.

Squat Jump (SJ) and Countermovement jump (CMJ) were also measured. Participants performed the SJ with feet parallel and shoulder-width apart, have a good balance in an upright position with the trunk remaining as vertical as possible, and hands-on the hips throughout the test knee angle around 90°. The trial was not considered valid if any movement was perceived with the increased knee flexion at the start of the jump<sup>22</sup>. For the CMJ, participants started from an upright standing position. They made a preliminary downward movement by flexing the knees and hips with a knee angle around 90° at the end of the countermovement. The research recorded the best of 3 trials (separated

with at least 1-min of recovery) for SJ and CMJ<sup>4</sup>. The results of CMJ height are in centimeters (cm). The CMJ test analyzed height using the MyJump app installed on an iPhone 6, which includes a 120 Hz high-speed camera at a quality of 720 p. MyJump calculated the time (in ms) between 2 frames selected by the user and subsequently, JH using the following equation:  $JH = FT^2 \times 1.22625$  (2). A researcher lay prone on the ground with the iPhone 6 facing the participant (in the frontal plane) ~1.5 m from the participant and zoomed in on the fighter's feet<sup>21</sup>.

## Statistical analysis

The Kolmogorov-Smirnov test (K-S) determined the normal distribution of the data. The descriptive parametric data presented by mean±SD. For the frequencies/non-parametric data, the descriptive data showed median (first quartile, third quartile). The Kruskal-Wallis test compared personality categories. Next, the Pearson's correlation coefficient and Spearman's rank correlation coefficient verified the relationship between the five factors of BFI and physical and mental variables using the classification: .00-.19 "very weak"; .20-.39 "weak"; .40-.59 "moderate"; .60-.79 "strong," and; .80-1.0 "very strong." The present analysis used a significance level of  $p \leq .05$  (SPSS 20.0 for Windows).

## RESULTS

Figure 1 shows the descriptive analysis of the Big Five Inventory of boxers. No effects between Big Five Factors frequencies were observed ( $p > 0.05$  for all comparisons).



**Figure 1.** Descriptive analysis of personality, separated by Big Five Factors.

Table 1 demonstrates the correlations between personality factors, power, and strength and endurance measures. There was a significant inverse correlation between agreeableness and sit-up ( $r=0.72$ ;  $p=0.02$ ).

Statistical analysis of SMQT associated with personality factors are presented in Table 2. There was a significant correlation between neuroticism and control ( $r=0.76$ ;  $p \leq 0.01$ ), constancy ( $r=0.84$ ;  $p \leq 0.01$ ) and total SMQT score ( $r=0.84$ ;  $p \leq 0.01$ ).

**Table 1.** Descriptive analysis of power, strength and endurance measures associated with personality factors of boxing practitioners.

Variables	Descriptive analysis Mean±SD	Extraversion		Agreeableness		Conscientiousness		Neuroticism		Openness	
		R-value	p-value	R-value	p-value	R-value	p-value	R-value	p-value	R-value	p-value
SJ height (cm)	21.6±7.3	0.13	0.7	0.53	0.09	-0.3	0.37	0.03	0.92	0.23	0.49
CM height (cm)	23.4±7.7	0.37	0.27	0.32	0.33	-0.14	0.67	0.15	0.65	0.35	0.29
Handgrip (Kgf)	44.2±21.7	-0.09	0.81	0.59	0.07	-0.3	0.4	0.23	0.52	-0.03	0.93
Sit-up (freq./min)	40.9±12.4	-0.06	0.87	0.72*	0.02	-0.3	0.4	-0.09	0.8	-0.05	0.89

\*Strong correlation, p&lt;0.05.

**Table 2.** Descriptive analysis of mental toughness associated with personality factors of boxing practitioners.

SMQT	Descriptive analysis Median (Q1; Q3)	Extraversion		Agreeableness		Conscientiousness		Neuroticism		Openness	
		R-value	p-value	R-value	p-value	R-value	p-value	R-value	p-value	R-value	p-value
Confidence	17 (15; 17)	0.1	0.78	-0.14	0.69	0.37	0.26	-0.06	0.87	0.29	0.39
Control	10 (9; 12)	0.19	0.57	0.34	0.3	0.01	0.98	0.76*	≤0.01	0.29	0.39
Constancy	10 (9; 12)	0.17	0.61	0.2	0.55	-0.12	0.73	0.84*	≤0.01	0.48	0.13
Total	37 (34; 37)	0.23	0.5	0.2	0.56	-0.09	0.8	0.84*	≤0.01	0.53	0.1

SMQT – Sports Mental Toughness Questionnaire. \*Strong correlation, p&lt;0.05.

## DISCUSSION

The present study demonstrated that personality could be considered a contextual factor that influences physical and mental boxing performance. Our results confirmed a significant and robust correlation between the agreeableness factor and the sit-ups test and strong correlations between Neuroticism, Control, Constancy, and Total SMQT scores. These data showed that neuroticism and endurance results correlate with boxers' personality whose drive motivates them relentlessly towards success and promotes thriving in boxing training environments or during championships.

Sports psychology has rarely examined the effect of personality traits in understanding mental toughness and Physical responses<sup>23</sup>. In taekwondo, personality traits, especially agreeableness and neuroticism, were useful in understanding arousal responses to the competition<sup>22</sup>. Preceding authors have suggested that self-efficacy mediated the relationship between the Big Five personality traits and self-control in boxing<sup>24</sup>. Our findings suggest a positive association between personality, mental toughness, and physical performance<sup>4</sup>. These results agree with preceding reports linking physical capabilities with emotional control<sup>11,25,26</sup>. However, previous authors have indicated a relationship between mental toughness and muscular power in kickboxing, and findings showed that athletes who had high mental toughness demonstrated greater muscular strength<sup>4</sup>. This correlation explained by muscular power gains must accompany strong brain activation relevant to the intended muscle action. Previous research has shown a proportional relationship between the magnitude of the brain-to-muscle signal and voluntary muscle force by young human subjects. At the same time, another study indicated that greater strength is associated with mental training<sup>6,27</sup>. The ability to regulate emotion and imagery successfully

shows commitment and determination, possessing an uncontrollable desire to succeed and unshakeable confidence, which are all particularities of mentally tough individuals and could differentiate athletes' levels.

The present study presented similar non-professional athletes and lower values than high-level boxing athletes who showed a high peak and anaerobic power output<sup>3</sup>. Therefore, muscle strength in both the upper and lower limbs is paramount for a fighter's performance<sup>12</sup> and is one of the keys to success in striking combats<sup>6,28</sup>. As boxing punches are quick and fast actions, high-level boxing performance requires well-developed muscle power in both the upper and lower limbs. Findings agree with preceding reports, which reveal that isometric strength is related to high-level boxing performance and torque production<sup>29</sup>. Future investigations into the mental toughness and physical attributes of boxers are essential to improve the current data set and help create a suitable training program.

## CONCLUSIONS

The present study confirms that personality can be considered a contextual factor that influences physical and mental boxing performance. Our results demonstrate a strong association between the agreeableness factor and the sit-ups test and powerful associations between Neuroticism, Control, Constancy, and Total SMQT scores. These data indicated that neuroticism and endurance results are associated with boxers' personalities whose drive persistently encourages them to succeed and helps them thrive in boxing training situations or during matches.

## COMPLIANCE WITH ETHICAL STANDARDS

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### Ethical approval

Ethical approval was obtained from the Federal University of Rio de Janeiro Research Ethics Committee and the protocol (no. 3.722.914) was written in accordance with the standards set by the Declaration of Helsinki.

### Conflict of interest statement

The authors have no conflict of interests to declare.

### Author Contributions

Conceived and designed the experiments: CJB, ALSC, VTM, VC, BM; Performed the experiments: CJB, MAB, VTM, ASN; Analyzed the data: MAB, FGT, DASS, BM; Contributed reagents/materials/analysis tools: VTM, ALSC, MAB; Wrote the paper: CJB, MAB, VTM, VC, BM.

## REFERENCES

1. Barrett J, Eason CM, Lazar R, Mazerolle SM. Personality traits and burnout among athletic trainers employed in the collegiate setting. *J Athl Train* 2016;51(6):454-9. <http://dx.doi.org/10.4085/1062-6050-51.7.08>. PMID:27415851.
2. Binboga E, Guven S, Çatıkkaş F, Bayazıt O, Tok S. Psychophysiological responses to competition and the big five personality traits. *J Hum Kinet* 2012;33:187-94. <http://dx.doi.org/10.2478/v10078-012-0057-x>. PMID:23486906.
3. Blake H, Hawley H. Effects of Tai Chi exercise on physical and psychological health of older people. *Curr Aging Sci* 2012;5(1):19-27. <http://dx.doi.org/10.2174/1874609811205010019>. PMID:21762093.
4. Bojanić Ž, Nedeljković J, Šakan D, Mitić PM, Milovanović I, Drid P. Personality traits and self-esteem in combat and team sports. *Front Psychol* 2019;10:2280. <http://dx.doi.org/10.3389/fpsyg.2019.02280>. PMID:31649595.
5. Box AG, Feito Y, Brown C, Petruzzello SJ. Individual differences influence exercise behavior: how personality, motivation, and behavioral regulation vary among exercise mode preferences. *Heliyon* 2019;5(4):e01459. <http://dx.doi.org/10.1016/j.heliyon.2019.e01459>. PMID:31065599.
6. Brandt R, Bevilacqua GG, Coimbra DR, Pombo LC, Miarka B, Lane AM. Body weight and mood state modifications in mixed martial arts: an exploratory pilot. *J Strength Cond Res*. 2018;32(9):2548-54. <http://dx.doi.org/10.1519/JSC.0000000000002639>. PMID:29927894.
7. Chaabène H, Franchini E, Miarka B, Selmi MA, Mkaouer B, Chamari K. Time-motion analysis and physiological responses to karate official combat sessions: is there a difference between winners and defeated karatekas? *Int J Sports Physiol Perform* 2014;9(2):302-8. <http://dx.doi.org/10.1123/ijsp.2012-0353>. PMID:23881174.
8. Chen MA, Cheesman DJ. Mental toughness of mixed martial arts athletes at different levels of competition. *Percept Mot Skills* 2013;116(3):905-17. <http://dx.doi.org/10.2466/29.30.PMS.116.3.905-917>. PMID:24175462.
9. Cimadoro G. Acute neuromuscular, cognitive and physiological responses to a Japanese kickboxing competition in semi-professional fighters. *J Sports Med Phys Fitness* 2017;58(12):1720-7. PMID:29083128.
10. Coswig VS, Gentil P, Bueno JC, Follmer B, Marques VA, Vecchio FB. Physical fitness predicts technical-tactical and time-motion profile in simulated judo and Brazilian jiu-jitsu matches. *PeerJ* 2018;6:e4851. <http://dx.doi.org/10.7717/peerj.4851>. PMID:29844991.
11. Slimani M, Miarka B, Briki W, Cheour F. Comparison of mental toughness and power test performances in high-level kickboxers by competitive success. *Asian J Sports Med* 2016;7(2):e30840. <http://dx.doi.org/10.5812/asj.30840>. PMID:27625755.
12. Coswig VS, Gentil P, Irigon F, Vecchio FB. Caffeine ingestion changes time-motion and technical-tactical aspects in simulated boxing matches: a randomized double-blind PLA-controlled crossover study. *Eur J Sport Sci* 2018;18(7):975-83. <http://dx.doi.org/10.1080/17461391.2018.1465599>. PMID:29738282.
13. Coswig VS, Miarka B, Pires DA, Silva LM, Bartel C, Vecchio FB. Weight regain, but not weight loss, is related to competitive success in real-life mixed martial arts competition. *Int J Sport Nutr Exerc Metab* 2019;29(1):1-8. <http://dx.doi.org/10.1123/ijsnem.2018-0034>. PMID:29757051.
14. Ewart CK, Stewart KJ, Gillilan RE, Kelemen MH. Self-efficacy mediates strength gains during circuit weight training in men with coronary artery disease. *Med Sci Sports Exerc* 1986;18(5):531-40. <http://dx.doi.org/10.1249/00005768-198610000-00007>. PMID:3773670.
15. Ghoul N, Tabben M, Miarka B, Tourny C, Chamari K, Coquart J. Mixed martial arts induces significant fatigue and muscle damage up to 24 hours post-combat. *J Strength*

- Cond Res 2019;33(6):1570-9. <http://dx.doi.org/10.1519/JSC.0000000000002078>. PMID:28658085.
16. Giovani D, Nikolaidis PT. Differences in force-velocity characteristics of upper and lower limbs of non-competitive male boxers. *Int J Exerc Sci* 2012;5(2):106-13. PMID:27182379.
  17. James LP, Haff GG, Kelly VG, Beckman EM. Towards a determination of the physiological characteristics distinguishing successful mixed martial arts athletes: a systematic review of combat sport literature. *Sports Med* 2016;46(10):1525-51. <http://dx.doi.org/10.1007/s40279-016-0493-1>. PMID:26993133.
  18. Jansen P, Dahmen-Zimmer K, Kudielka BM, Schulz A. Effects of karate training versus mindfulness training on emotional well-being and cognitive performance in later life. *Res Aging* 2017;39(10):1118-44. <http://dx.doi.org/10.1177/0164027516669987>. PMID:27688143.
  19. Kotarska K, Nowak L, Szark-Eckardt M, Nowak MA. Intensity of health behaviors in people who practice combat sports and martial arts. *Int J Environ Res Public Health* 2019;16(14):2463. <http://dx.doi.org/10.3390/ijerph16142463>. PMID:31373295.
  20. Liu M, So H. Effects of Tai Chi exercise program on physical fitness, fall related perception and health status in institutionalized elders. *J Korean Acad Nurs* 2008;38(4):620-8. <http://dx.doi.org/10.4040/jkan.2008.38.4.620>. PMID:18753814.
  21. Lochbaum MR, Rhodes RE, Stevenson SJ, Surles J, Stevens T, Wang CK. Does gender moderate the exercising personality? An examination of continuous and stage-based exercise. *Psychol Health Med* 2010;15(1):50-60. <http://dx.doi.org/10.1080/13548500903443449>. PMID:20391224.
  22. Massuca L, Branco B, Miarka B, Fragoso I. Physical fitness attributes of team-handball players are related to playing position and performance level. *Asian J Sports Med* 2015;6(1):e24712. <http://dx.doi.org/10.5812/asjasm.24712>. PMID:25883775.
  23. Vieira LF, Fernandes SL, Vieira JLL, Vissoci JRN. Estado de humor e desempenho motor: um estudo com atletas de voleibol de alto rendimento. *Rev Bras Cineantropom Des Hum* 2008;10(1):62-8. <http://dx.doi.org/10.5007/1980-0037.2008v10n1p62>.
  24. Pędzich W, Mastalerz A, Sadowski J. Estimation of muscle torque in various combat sports. *Acta Bioeng Biomech* 2012;14(4):107-12. PMID:23394114.
  25. Silva B, Clemente FM, Martins FM. Associations between functional movement screen scores and performance variables in surf athletes. *J Sports Med Phys Fitness* 2018;58(5):583-90. PMID:28229573.
  26. Slimani M, Chaabene H, Miarka B, Franchini E, Chamari K, Cheour F. Kickboxing review: anthropometric, psychophysiological and activity profiles and injury epidemiology. *Biol Sport* 2017;34(2):185-96. <http://dx.doi.org/10.5114/biolSport.2017.65338>. PMID:28566813.
  27. Whiting SW, Hoff RA, Balodis IM, Potenza MN. An exploratory study of relationships among five-factor personality measures and forms of gambling in adults with and without probable pathological gambling. *J Gambl Stud* 2019;35(3):915-28. <http://dx.doi.org/10.1007/s10899-018-9809-4>. PMID:30382456.
  28. Zhang G, Chen X, Xiao L, Li Y, Li B, Yan Z, et al. The relationship between big five and self-control in boxers: a mediating model. *Front Psychol* 2019;10:1690. <http://dx.doi.org/10.3389/fpsyg.2019.01690>. PMID:31440177.
  29. Znazen H, Slimani M, Miarka B, Butovskaya M, Siala H, Messaoud T, et al. Mental skills comparison between elite sprint and endurance track and field runners according to their genetic polymorphism: a pilot study. *J Sports Med Phys Fitness* 2017;57(9):1217-26. <http://dx.doi.org/10.23736/S0022-4707.16.06441-0>. PMID:27441913.