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CHANGES OF MOOD AND ATTENTION DIVISIBILITY IN ROWERS EXPOSED TO HIGH-INTENSITY TRAINING

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SUMMARY

Background: Higher probability of succeeding in competitive sports is to a large extent associated with psychological preparation. Emotional and cognitive functioning are important factors that can modulate the attitude of competitive athletes and be reflected by their sports achievements. Participation in high-intensity training, being both physically and psychologically taxiing, can exert significant effect on mood changes and attention divisibility.

Material/ Methods: The study included 10 male rowers, members of the Polish National Rowing Team, who participated in an 8-week high-intensity training program. The participants were examined with the UMACL mood survey and computer test for attention divisibility. Moreover, their blood cortisol levels were determined.

Results: No significant associations between mood and blood cortisol level were documented. The level of tension arousal decreased significantly between the first and second measurement, suggesting that our athletes experienced the highest level of stress immediately prior to the high-intensity training program. Moreover, we observed strong correlations between good mood, manifested by high levels of hedonic tone, and poor results of the attention divisibility test.

Conclusions: The results of mood testing support the postulate on cooperation with sports psychologists in the management of athletes' emotions. Moreover, individualized meticulous interviews should be conducted with athletes, and their results should be analyzed in conjunction with the results of physiological measurements, in order to comprehensively explore the relationship between psychological and somatic stress.

key words: mood, divided attention, cortisol, high-intensity training

INTRODUCTION

During the recent 2012 Summer Olympic Games in London, the difference between the winners and the second team in men's eights rowing race amounted to only 1.75 second (http://www.olympic.org/olympic-results/london-2012/ rowing). This is only one of many examples illustrating small differences between athletes competing for a championship. This results in a huge pressure experienced by athletes, and in searching for ways to increase the probability of success, mostly in terms of psychological preparation (Birrer & Morgan, 2010). However, mental training should be properly adjusted to both psychological and physiological demands of particular disciplines. Apart from kayaking, triathlon and speed skating, also rowing is listed among sports disciplines that require high intensity training (Mitchell, Haskell, Snell & Van Camp, 2005). Competitive rowing requires maximum physical exertion that lasts between 1 and 8 minutes and is characterized by equally high intensity for the whole task phase (Birrer & Morgan, 2010). Emotional reactions represent additional strain that significantly modulates cardiovascular overload in athletes (Mitchell, Haskell, Snell & Van Camp, 2005). An athlete being exposed to too exhausting training, not only experiences overtraining and resultant deterioration of physical capability, but also suffers from a decrease in cognitive potential and emotional resistance (Siewierski, 2005). However, diagnosing overtraining is not easy; it should be based on the values of biochemical markers and self-reported scales, as well as on monitoring sports achievements (Halson & Jeukendrup, 2004). Analysis of psychological mood and simultaneous collection of physiological data, allows systematic control of effects that training exerts on an athlete's body (Jürimäe, Purge, Mäestu & Jürimäe, 2004; Steinacker et al., 2000).

The proportion between positive and negative emotions experienced during training and competition can differ, depending on a sports level presented by a given athlete (Martinent, Nicolas, Gaudreau & Campo, 2013). Previous studies (Lane, Thelwell & Devonport, 2009) revealed that the mood associated with the feeling of physical readiness, which is referred to as vigor (being associated with energy and alertness), and weariness (feelings of fatigue and exhaustion) can significantly modulate physical efficiency of the performed sports tasks. Deep concentration on a task, presence of positive emotions and complete involvement in performed activities, feelings of being in control over a situation and environment, undertaking of spontaneous actions, and immediate response to any changes constitute the most desirable mental states during competition. The state described above is referred to as a flow (Jackson & Csikszentmihalyi, 1999). However, challenges associated with sports competition can frequently stimulate an emotional reaction, which is reflected by poorer performance of a task that was practiced during training (Balk, Adriaanse, de Ridder & Evers, 2013). Cortical processes that regulate the reaction of body to new stimuli should be activated in such situations, to enable optimal performance of an undertaken activity. However, this can be challenging in an emotional situation which is additionally associated with a pressure of time, as cortical processing of an impulse may last too long and thus a response will originate from lower level of processing, i.e. from the limbic system (Pąchalska, Lipowska & Łukaszewska, 2007). Previous research (Laborde, Lautenbach, Allen, Herbert & Achtzehn, 2014) showed that analyzing the probability of succeeding in sports in a situation of pressure, one should also consider the blood cortisol level of the athlete. High blood concentration of cortisol was revealed to decrease the probability of overcoming challenges in sports (Doan, Newton, Kraemer, Kwon & Scheet, 2007). Moreover, changes in secretion of testosterone and cortisol seem to moderate the results of training and long-term adaptation in some athletes; thus, collecting individualized data on the levels of these hormones can be used for the development of optimal training program for an elite athlete (Crewther, Cook, Cardinale, Weatherby & Lowe, 2011).

Another important issue, which is associated with the process of individualizing effects of physical training and specialist mental training for athletes, is cognitive functioning of the latter. The processes of decision making, anticipation, memorizing, perception, visualization, rumination and concentration are of vital importance in this matter (Moran, 2009, 2012; Krokosz, Jochimek & Lipowski, 2013). Moreover, optimal concentration is associated with a state which is referred to as flow (Jackson & Csikszentmihalyi, 1999). One of the methods proposed by psychologists of sport is mindfulness technique, i.e. the ability to concentrate on a given task „here and now"; also, this technique allows to activate the flow status (Aherne, Moran & Lonsdale, 2011). Also neurofeedback is a dynamically developing branch of sports psychology and popular method of providing support for athletes (Berka, Behneman, Kintz, Johnson & Raphael, 2010; Ziółkowski et al., 2012). Spontaneous EEG of a healthy brain depicts a mixture of various rhythmicities, which are traditionally separated into alpha, theta and beta rhythms. Recent research showed that each of these rhythmicities is generated by a specific neuronal network (the posterior and central alpha rhythms are generated by thalamocortical networks, beta rhythms appear to be generated by local cortical networks, while the frontal midline theta rhythm, which is the only healthy theta rhythm in the human brain, is presumably generated by the septohippocampal neuronal network). In general terms, spontaneous oscillations reflect mechanisms of cortical self-regulation, implemented by several neuronal mechanisms (Kropotov, Mueller, 2009; Kropotov, 2009). Studies using a 56-channel electroencephalograph revealed that cortical frequencies of alpha waves recorded in either successful or unsuccessful athletes differ from those documented for untrained individuals (Del Percio et al., 2009). Knowledge of individual differences stimulates a search for methods that would stimulate optimal pattern of cortical activity in an athlete. This goal can be achieved with neurofeedback, which represents one of the most promising methods of improving one's performance on a way to championship (Vernon, 2005). This attitude fits into a previous research in a field of cognitive psychology in sports, which focused on concentration, decision making, memorizing and perception (Furley & Memmert, 2013). Attention divisibility seems particularly important from a rower's perspective, as it enables self-adjustment of one's rhythm of rowing to those of other partners, and simultaneous analysis of acoustic signals associated with the boat's movement: either the discipline-specific strokes, or signals emitted by an accessory state-of-the-art equipment, indicating an optimal rhythm of rowing in a given moment (Schaffert, Mattes & Effenberg, 2010).

The aim of this study was to analyze the relationship between subjectively perceived moods of athletes and their blood levels of cortisol, determined during high intensity training. As both the level of cortisol and the mood can modulate cognitive functioning (Crewther, Cook, Cardinale, Weatherby & Lowe, 2011; Moran 2009; Vast, Young & Thomas, 2010; McCarthy, Allen & Jones, 2013), the influence of these factors on the attention divisibility of athletes seems of particular importance.

MATERIAL AND METHODS

The study included 10 male rowers, aged between 20 and 25 years (M = 22.00, SD = 1.41), who participated in an 8-week high-intensity training program. All the participants were the members of Academic National Rowing Team, and regularly took part in training camps. Although this sample may seem small from the methodological perspective, in fact, it represented considerable percentage of all Polish elite rowers.

The level of mood of the athletes was determined with UWIST Mood Adjective Check List (UMACL) by Mathews, Chamberlain & Jones, adapted into Polish by Goryńska (2005). During the test, the athletes scored (on a scale from 1 to 4) the degree to which their present mood was described by each of the 29 listed adjectives. The final score is represented by three dimensions: energetic arousal (EA), tense arousal (TA) and hedonic tone (HT). High levels of energetic arousal correspond to such feelings as being restful, energetic and vigorous, and high scores of tense arousal to being stressed, anxious or tense. Hedonic tone was associated with being cheerful, satisfied and happy (high scores), or concerned, depressed and sad (low scores) (Goryńska, 2005). Before completing the test, the athletes were asked about any potential situations unrelated to training that could modify their mood, but no such factors were declared. Cognitive skills (attention divisibility) were determined with a subtest included in the Battery of Computer Tests for Coordination Skills by Klocek, Spieszny & Szczepanik (2002). The athletes were asked to press a „Q" button on a computer keyboard as soon as an appropriate sequence of geometric figures appeared in the center of a computer screen, and a „1" button whenever four squares appeared simultaneously in all four corners of the screen. Therefore, the athletes should have been focusing their attention on both the center and the periphery of their field of vision. The final attention score was calculated by the computer software, based on the number of correct hits, missed hits and overreactions. The results were presented on a scale corresponding to the grading system in Polish schools, i.e. from 1 (the worst score) to 6 (excellent score).

The experiment comprised of three measurements at 4-week intervals. The first measurement took place on March 21st, 2013 prior to the training program, and the follow-up visits were scheduled on April 19th and May 15th, 2013 Each visit begun with obtaining a blood sample for cortisol level, followed by completing the UMACL survey and computer test for attention divisibility, both conducted in an isolated room. Between the visits, the athletes participated in high-intensity rowing trainings, comprised of long-distance running, exercises on a rowing ergometer and rowing in a real boat on water. The training program lasted 8 weeks. All the measurements were taken in the morning hours in order to eliminate circadian variability of blood cortisol levels. The level of cortisol were determined by analyzer Cobas Mira plus E411 (Roche Diagnostic GMBH, Muenchen, Germany, 2009) using reagent Cortizol (reference number:11875116).

RESULTS

Only a slight, statistically insignificant, fluctuations in the blood cortisol level were observed during the study period. The level of cortisol remained within the normal range, i.e. between 150 nmol/l and 700 nmol/l (Szutowicz, Raszei-Specht, 2009). Moreover, no significant correlations were documented between the blood cortisol levels and moods of athletes, or their attention scores.

Our athletes presented with moderate level of mood at each of three visits, and visit-to-visit differences in this parameter reached only a threshold of statistical trend. However, the analysis of individual cases revealed that at the first visit, the profiles of 20% of the athletes corresponded to a depressive mood (low levels of energetic arousal and hedonic tone, and high level of tense arousal). Similar phenomenon was not observed during the second and third visit. However, none of the individual profiles corresponded to a very good mood. Moreover, we observed visit-to-visit differences in individual dimensions of mood. Repeated measures analysis of variance showed significant effect of time on tense arousal: $F(2, 18) = 8.22$; $p = 0.002$, and post-hoc analysis with Tukey test revealed that the level of energetic arousal during the first visit was significantly higher than at the second visit ($p = 0.013$; Table 1).

We did not observe significant differences in the results of the attention divisibility tests conducted at various stages of the training program. Although the le-

Tab. 1. Dimensions of mood during three consecutive measurements

	Measurement 1		Measurement 2		Measurement 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
Energetic arousal	30.30	3.49	31.40	3.43	31.50	2.00
Tense arousal	18.60	3.80	13.90	2.76	15.20	4.26
Hedonic tone	32.30	4.21	33.20	2.14	31.20	4.26

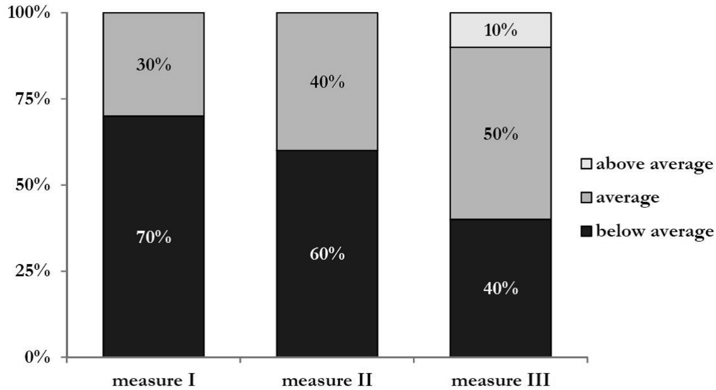

Fig. 1. Distribution of the results of attention divisibility test in relation to respective reference values

vels of attention score increased from visit to visit, none of the changes reached the threshold of statistical significance.

Similarly, we did not document statistically significant differences in the number of missed hits (not pressing the button when required) and overreactions (pressing the button when not required).

Qualitative analysis and comparison with the reference values revealed that the attention scores achieved during the first two visits were below the average in most athletes. The only above the average score was documented during the third visit. The distribution of attention scores of our athletes is presented on Figure 1. Our findings suggest that the athletes did not score higher, excepting the possibility that they got used to the experimental conditions.

The analysis of *r*-Spearman's correlation revealed a number of significant relationships between the dimensions of mood and the results of the attention di-

Tab 2. Correlations between the dimensions of mood and the results of attention divisibility test

Scale	*Energetic arousal*		*Tense arousal*		*Hedonic tone*	
Missed hits						
Measurement 1	.20		-.20		-.02	
Measurement 2	.28		-.13		.66	(.035)
Measurement 3	-.03		-.04		-.10	
Overreactions						
Measurement 1	.32		-.13		.29	
Measurement 2	.76	(.010)	-.77	(.008)	.51	
Measurement 3	.01		.09		.28	
Attention score						
Measurement 1	-.47		.19		-.67	(.032)
Measurement 2	-.56		.41		-.74	(.013)
Measurement 3	.09		-.03		.04	

Note: r (p)

visibility test (Table 2). The results suggest that the better one's mood (i.e. the lower tense arousal level and the higher energetic arousal and hedonic tone levels), the poorer the results of the attention divisibility test (higher numbers of missed hits and overreactions, and lower attention scores).

DISCUSSION

Interestingly, we did not observe a significant association between declared mood, especially the level of tense arousal, and blood cortisol level. In contrast, published data point to the presence of such a relationship. Cohen, Janicki-Deverts & Miller (2007) documented significant positive association between the level of self-reported stress and blood concentration of cortisol. However, Jobin, Warsch & Scheier (2013) identified factors that can affect this relation, namely, personality-related variables (such as the sense of optimism), and suggested that association between the level of cortisol and declared mood should be analyzed on an individual basis. Furthermore, Miller Chen & Zhou (2007) and Wust, Fedorenko, van Rossum, Koper & Hellhammer (2005) emphasized the role of habituation to stressful conditions, that can result in a decrease in cortisol secretion. Undoubtedly, the elite athletes, who participate in a number of highly-burdensome training camps, trainings and competitions, are to a large extent accustomed to stressful conditions. This can significantly modulate their blood concentrations of cortisol on the one hand, and influence subjectively perceived mood on the other. Our findings are consistent with those reported by Mäestu, Jürimäe, Kreegipuu & Jürimäe (2006), who observed that changes in the levels of self-reported stress and the ways of coping with stress by intensively-trained Finnish rowers were not associated with simultaneous changes in the level of cortisol. Moreover, the analysis of research dealing with physiological response to acute stress suggests that the latter reaction is less pronounced in physically active individuals (Taylor, Biddle, Fox & Boutcher, 2001). Interestingly, a 10-day high-intensity interval training did not modulate the levels of cortisol during performing a task that induced psychological stress (Ormsbee et al., 2013). Perhaps, this suggests that the duration of the training was too short to stimulate positive effects. The aim of intensive training is to improve an athlete's performance (Jastrzębski, Barnat, Konieczna, Rompa & Radzimiński, 2011), and thus his/her perception of energy. Consequently, it is noteworthy that we did not observe a significant increase in the level of energetic arousal, especially when the initial two measurements were compared with the third one. Similar results were previously reported by Oliveira, Slama, Deslandes, Furtado & Santos (2013), who compared the effects of high-intensity interval training and continuous training on athletes' moods. Although these authors determined mood with a different instrument, Profile of Mood States (McNair, Lorr & Droppleman, 1971), the 'vigor' dimension of this scale corresponded to energetic arousal analyzed in our study. The above-mentioned association was also confirmed by the results of meta-analysis of mood changes in elite athletes subjected to high-intensity exercise

(Peluso & Andrade, 2005). Therefore, it can be concluded that physiological indices of higher energy levels in an athlete are not directly reflected by a subjectively perceived psychological mood. One potentially interesting direction of future research is the dynamics of changes in the sense of energetic arousal in a longer perspective, after completing intensive training. Higher levels of tense arousal observed during the first stage of our study are worth emphasizing. This may suggest that our athletes perceived fear and declared being stressed during this period. Despite the previously mentioned habituation of athletes to difficult conditions associated with intensive training and competition, the levels of arousal observed in two of our athletes resembled those characteristic for a depression profile. This is particularly surprising in view of the numerous data suggesting that practicing sport protects against mood depression (Lipowski, 2012; Guszkowska, 2013; Jorm, Morgan & Wright, 2010). The fact that this relationship was observed only during the first stage of the study is consistent with data on systematic increase in the level of somatic anxiety, which reaches its peak values during involvement in a challenging task. However, the level of somatic anxiety decreases rapidly after beginning a stressful activity (Swain & Jones, 1993); this phenomenon was observed in our study as well. Also, a review of the available data (Peluso & Andrade, 2005) suggests that such relationship is present in competitive athletes: they show a depression of psychological mood between the first and the second phase of the yearly training cycle, and its improvement is observed no earlier than between the second and third phase, i.e. during direct preparation to competition. Consequently, including the data on psychological mood of athletes exposed to high-intensity training into a protocol of neuropsychological diagnosis would be particularly interesting. Previous neuropsychological studies revealed that individuals suffering from depression and the controls differ in terms of alpha-, beta- and theta-wave patterns (Grin-Yatsenko, Baas, Ponomarev & Kropotov, 2010). Consequently, one may ask if neurotherapy could efficiently modulate the mood of athletes being exposed to intensive exercise. A number of authors documented successful use of neurofeedback in improving a patients' performance (Kropotov et al., 2007; Pąchalska et al., 2012a, 2012b). Positive neurofeedback-induced changes in memory, attention, creativity and mood were also observed in sportspersons, and thus this method is considered as a highly promising way of achieving peak performance in athletes (Rostami, Sadeghi, Karami, Abadi & Salamati, 2012; Thompson, Steffert, Ros, Leach & Gruzelier, 2008). Therefore, neurofeedback constitutes an excellent instrument that can be used to mobilize energetic reserves of athletes; in view of small differences between a winner and loser, utilization of these reserves can be crucial for winning a championship. Moreover, the role of neurofeedback as an adjuvant rehabilitation method in athletes who experienced injury or suffer from chronic pain should be highlighted (Jensen et al., 2013; May, Benson, Balon & Boutros, 2013).

Also the correlation between positive mood and decreased attention score is worth noticing. Previous studies revealed an association between higher levels of mood or excitation and a lower number of impulsive choices (Weafer, Baggott

& de Wit, 2013; Pachalska, Kaczmarek & Kropotov 2014). However, our study produced contradictory findings, as we observed an inverse correlation between the level of tense arousal and the number of overreactions. Perhaps our rowers showed a more vigorous and joyful attitude to a task performed under laboratory conditions, and thus considered it as less important, which was reflected by their lower motivation to complete the test correctly. Moreover, our findings may reflect a task-oriented functioning of the examined sportsmen. One should think about an optimal level of arousal that would determine success, i.e. outstanding sports achievements of our athletes. Too high levels of satisfaction, happiness and vigor may be reflected by a tendency to overreaction, which can lead to a false start during competition. Furthermore, the athletes with the above-mentioned characteristics may experience difficulties in maintaining appropriate synchronization of rhythm during rowing, as this activity is associated not only with speed but also with precision, difficult to achieve for persons who are prone to overreaction. Consequently, also neurotherapy-based interventions should be considered during preparation to a rowing competition, as the results of meta-analysis conducted by Arns, Ridder, Strehla, Breteler & Coenen (2009) suggest that this method is highly effective in the management of inattention and impulsiveness, present in patients with ADHD.

CONCLUSIONS

Psychologists of sport search for methods that would improve cognitive skills of athletes (Crewther, Cook, Cardinale, Weatherby & Lowe, 2011). The results of studies dealing with the central peripheral perception suggest that improvement of these skills can be reflected by better achievements in sports (Hüttermann, Memmert, Simons & Bock, 2013). Therefore, our analysis of attention divisibility during high intensity training seems justified. However, the fact that rowing is characterized by simultaneous processing of acoustic stimuli and adequate modulation of the rhythm of rowing (Schaffert, Mattes & Effenberg, 2010), should be considered during future research.

The hereby presented results of mood testing support the postulate on cooperation with sports psychologists in the management of athletes' emotions. Moreover, individualized meticulous interviews should be conducted with athletes and their results should be analyzed in conjunction with the results of physiological measurements, in order to comprehensively explore the relationship between psychological and somatic stress. An interdisciplinary analysis of an athlete's functioning, including his/her affective status, cognitive functioning and physiological responses seems equally useful. Finally, the neurotherapy, increasingly used during work with athletes, also in Poland, represents another promising direction of future research.

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REFERENCES

Aherne, C., Moran, A. P., & Lonsdale, C. (2011). The Effect of Mindfulness Training on Athletes' Flow: An Initial Investigation. *Sport Psychologist*, *25*(2), 177-189.

Arns, M., de Ridder, S., Strehl, U., Breteler, M., & Coenen, A. (2009). Efficacy of neurofeedback treatment in ADHD: the effects on inattention, impulsivity and hyperactivity: a meta-analysis. *Clinical EEG and Neuroscience*, *40*(3), 180-189.

Balk, Y. A., Adriaanse, M. A., De Ridder, D. T., & Evers, C. (2013). Coping under pressure: employing emotion regulation strategies to enhance performance under pressure. *Journal of Sport & Exercise Psychology*, *35*(4), 408-418.

Berka, C., Behneman, A., Kintz, N., Johnson, R., & Raphael, G. (2010). Accelerating Training Using Interactive Neuro-Educational Technologies: Applications to Archery, Golf, and Rifle Marksmanship. *International Journal of Sports and Society*, *1*(4), 87-104.

Birrer, D., & Morgan, G. (2010). Psychological skills training as a way to enhance an athlete's performance in high intensity sports. *Scandinavian Journal of Medicine & Science in Sports*, *20*(s2), 78-87.

Cohen, S., Janicki-Deverts, D., & Miller, G. E. (2007). Psychological stress and disease. *JAMA*, *298*(14), 1685-1687.

Crewther, B. T., Cook, C., Cardinale, M., Weatherby, R. P., & Lowe, T. (2011). Two emerging concepts for elite athletes. *Sports Medicine*, *41*(2), 103-123.

Del Percio, C., Babiloni, C., Bertollo, M., Marzano, N., Iacoboni, M., Infarinato, F., Lizio, R., Stocchi, M., Robazza, C., Cibelli, G., Comani, S. & Eusebi, F. (2009). Visuo attentional and sensorimotor alpha rhythms are related to visuo motor performance in athletes. *Human Brain Mapping*, *30*(11), 3527-3540.

Doan, B. K., Newton, R. U., Kraemer, W. J., Kwon, Y. H., & Scheet, T. P. (2007). Salivary cortisol, testosterone, and T/C ratio responses during a 36-hole golf competition. *International Journal of Sports Medicine*, *28*(6), 470-479.

Furley, P., & Memmert, D. (2013). "Whom Should I Pass To?" The More Options the More Attentional Guidance from Working Memory. *PloS One*, *8*(5), 1-14.

Goryńska, E. (2005). *Przymiotnikowa Skala Nastroju UMACL, Gerald Matthews, A. Graham Chamberlain, Dylan M. Jones. Test. Adaptacja [UMACL, UWIST Mood Adjective Check List, Gerald Matthews, A. Graham Chamberlain, Dylan M. Jones. Test. Adaptation]* Warszawa: Pracownia Testów Psychologicznych Polskiego Towarzystwa Psychologicznego.

Grin-Yatsenko, V. A., Baas, I., Ponomarev, V. A., & Kropotov, J. D. (2010). Independent component approach to the analysis of EEG recordings at early stages of depressive disorders. *Clinical Neurophysiology*, *121*(3), 281-289.

Guszkowska, M. (2013). *Aktywność fizyczna i psychika: korzyści i zagrożenia [Physical activity and mentality: benefits and risks]*. Toruń: Wydawnictwo Adam Marszałek.

Halson, S. L., & Jeukendrup, A. E. (2004). Does overtraining exist? An Analysis of Overreaching and Overtraining Research. *Sports Medicine*, *34*(14), 967-981.

Hüttermann, S., Memmert, D., Simons, D. J., & Bock, O. (2013). Fixation strategy influences the ability to focus attention on two spatially separate objects. *PloS One*, *8*(6), e65673.

Jackson, S. A., & Csikszentmihalyi, M. (1999). *Flow in sports*. Human Kinetics.

Jastrzębski, Z., Barnat, W., Konieczna, A., Rompa, P., & Radzimiński, Ł. (2011). Changes of physical capacity and soccer-related skills in young soccer players within a one-year training period. *Baltic Journal of Health and Physical Activity*, *3*(4), 248-261.

Jensen, M. P., Gertz, K. J., Kupper, A. E., Braden, A. L., Howe, J. D., Hakimian, S., & Sherlin, L. H. (2013). Steps Toward Developing an EEG Biofeedback Treatment for Chronic Pain. *Applied Psychophysiology and Biofeedback*, *38*(2), 101-108.

Jobin, J., Wrosch, C., & Scheier, M. F. (2013). Associations Between Dispositional Optimism and Diurnal Cortisol in a Community Sample: When Stress Is Perceived as Higher Than Normal. *Health Psychology*. Advance online publication. doi: 10.1037/a0032736.

Jorm, A. F., Morgan, A. J., & Wright, A. (2010). Actions that young people can take to prevent depression, anxiety and psychosis: beliefs of health professionals and young people. *Journal of Affective Disorders*, *126*(1), 278-281.

Jürimäe, J., Purge, P., Mäestu, J., Jürimäe, T. (2004). Heavy training stress in male rowers: effects on circulatory responses and mood state profiles. *Kinesiology, 36*(2), 213-219.

Klocek, T., Spieszny, M., Szczepanik, M. (2002). *Komputerowe testy zdolności koordynacyjnych [Computer tests for coordination skills].* Warszawa: COS.

Krokosz, D., Jochimek, M., & Lipowski, M. (2013). Psychologiczne konsekwencje niewykorzystanych okazji w walce sportowej w grach indywidualnych i drużynowych [Psychological consequences of missed opportunities in individual and team sports competition]. In: Z. Jastrzębski (ed), *Teoria i praktyka wychowania fizycznego i sportu 3 [Theory and practice of physical education and sport 3]* (104-119). Łódź: Wyższa Szkoła Sportowa.

Kropotov, J. (2009). *Quantitative EEG, event-related potentials and neurotherapy*. Academic Press.

Kropotov, J. D., & Muller, A. (2009). What can event related potentials contribute to neuropsychology. *Acta Neuropsychologica*, *7*(3), 169-181.

Kropotov, J. D., Grin-Yatsenko, V. A., Ponomarev, V. A., Chutko, L. S., Yakovenko, E. A., & Nikishena, I. S. (2007). Changes in EEG spectrograms, event-related potentials and event-related desynchronization induced by relative beta training in ADHD children. *Journal of Neurotherapy*, *11*(2), 3-11.

Laborde, S., Lautenbach, F., Allen, M. S., Herbert, C., & Achtzehn, S. (2014). The role of trait emotional intelligence in emotion regulation and performance under pressure. *Personality and Individual Differences*, *57*, 43-47.

Lane, A. M., Thelwell, R., & Devonport, T. J. (2009). Emotional Intelligence and Mood States associated with Optimal Performance. *E-journal of Applied Psychology*, *5*(1), 67-73.

Lipowski, M.(2012). Level of optimism and health behavior in athletes. *Medical Science Monitor, 18*(1), 39-43.

May, G., Benson, R., Balon, R., & Boutros, N. (2013). Neurofeedback and traumatic brain injury: A literature review. *Annals of Clinical Psychiatry*, *25*(4), 289-296.

Mäestu, J., Jürimäe, J., Kreegipuu, K., & Jürimäe, T. (2006). Changes in Perceived Stress and Recovery During Heavy Training in Highly Trained Male Rowers. *Sport Psychologist*, *20*(1), 24-39.

Martinent, G., Nicolas, M., Gaudreau, P., Campo, M. (2013). A Cluster Analysis of Affective States Before and During Competition. *Journal of Sport & Exercise Psychology*, *35*, 600-611.

McCarthy, P. J., Allen, M. S., & Jones, M. V. (2013). Emotions, cognitive interference, and concentration disruption in youth sport. *Journal of Sports Sciences*, *31*(5), 505-515.

McNair, D.M., Lorr, M., Droppleman, L.F.(1997). *Manual for Profile of Mood States*. San Diego: Educational and Industrial Testing Service.

Miller, G. E., Chen, E., & Zhou, E. S. (2007). If it goes up, must it come down? Chronic stress and the hypothalamic-pituitary-adrenocortical axis in humans. *Psychological Bulletin*, *133*(1), 25– 45.

Mitchell, J. H., Haskell, W., Snell, P., & Van Camp, S. P. (2005). Task Force 8: classification of sports. *Journal of the American College of Cardiology*, *45*(8), 1364-1367.

Moran, A. (2009). Cognitive psychology in sport: Progress and prospects. *Psychology of Sport and Exercise*, *10*(4), 420-426.

Moran, A. (2012). Thinking in action: Some insights from cognitive sport psychology. *Thinking Skills and Creativity*, *7*(2), 85-92.

Oliveira, B. R., Slama, F. A., Deslandes, A. C., Furtado, E. S., & Santos, T. M. (2013). Continuous and high-intensity interval training: which promotes higher pleasure?. *PloS One*, *8*(11), 1-6.

Ormsbee, M. J., Kinsey, A. W., Chong, M., Friedman, H. S., Dodge, T., & Fehling, P. C. (2013). The Influence of High Intensity Interval Training on the Salivary Cortisol Response to a Psychological Stressor and Mood State in Non-Sedentary College Students. *Journal of Exercise Physiology Online*, *16*(1), 105-116.

Pachalska M., Kaczmarek B.L.J., Kropotov J.D. (2014) Neuropsychologia kliniczna: od teorii do praktyki. Warszawa: Wydawnictwo Naukowe PWN.

Pąchalska, M., Kropotov, I. D., Mańko, G., Lipowska, M., Rasmus, A., Łukaszewska, B., Bogdanowicz, M. & Mirski, A. (2012a). Evaluation of a neurotherapy program for a child with ADHD with Benign Partial Epilepsy with Rolandic Spikes (BPERS) using event-related potentials. *Medical Science Monitor*, *18*(11), CS94-104.

Pąchalska, M., Lipowska, M., Łukaszewska, B. (2007). Towards a process neuropsychology: mictrogenetic theory and brain science. *Acta Neuropsychologica, 5*(4), 228-245.

Pąchalska, M., Mańko, G., Kropotov, I. D., Mirski, A., Łukowicz, M., Jedwabińska, A., & Talar, J. (2012b). Evaluation of neurotherapy for a patient with chronic impaired self-awareness and secondary ADHD after severe TBI and long term coma using eventrelated potentials. *Acta Neuropsychologica*, *10*(3), 399-417.

Peluso, M. A. M., & Andrade, L. H. S. G. D. (2005). Physical activity and mental health: the association between exercise and mood. *Clinics*, *60*(1), 61-70.

Rostami, R., Sadeghi, H., Karami, K. A., Abadi, M. N., & Salamati, P. (2012). The Effects of Neurofeedback on the Improvement of Rifle Shooters' Performance. *Journal of Neurotherapy*, *16*(4), 264-269.

Schaffert, N., Mattes, K., & Effenberg, A. O. (2010). Listen to the boat motion: acoustic information for elite rowers. In *Human Interaction with Auditory Displays–Proceedings of the Interactive Sonification Workshop* (pp. 31-38).

Siewierski, M. (2005). Przyczynek do dyskusji nad obciążeniami psychofizycznymi w sporcie wyczynowym [Contribution to the discussion on a psychophysical burden in competitive sports]. *Kultura Fizyczna 1-2*, 23-25.

Steinacker, J. M., Lormes, W., Kellmann, M., Liu, Y., Reissnecker, S., Opitz-Gress, A., Baller, B., Günther, K., Petersen, K.G., Kallus, K.W., Lehmann, M., & Altenburg, D. (2000). Training of junior rowers before world championships. Effects on performance, mood state and selected hormonal and metabolic responses. *Journal of Sports Medicine and Physical Fitness*, *40*(4), 327-335.

Swain, A., & Jones, G. (1993). Intensity and frequency dimensions of competitive state anxiety. *Journal of Sports Sciences*, *11*(6), 533-542.

Szutowicz, A., Raszei-Specht, A. (2009). *Diagnostyka laboratoryjna T. I [Laboratory diagnostics Vol. 1]*. Gdańsk: Gdański Uniwersytet Medyczny.

Taylor, A. H., Biddle, S. J. H., Fox, K. R., & Boutcher, S. H. (2001). Physical activity, anxiety, and stress. *Physical Activity and Psychological Well-being*, 10-45.

Thompson, T., Steffert, T., Ros, T., Leach, J., & Gruzelier, J. (2008). EEG applications for sport and performance. *Methods*, *45*(4), 279-288.

Vast, R. L., Young, R. L., & Thomas, P. R. (2010). Emotions in sport: Perceived effects on attention, concentration, and performance. *Australian Psychologist*, *45*(2), 132-140.

Vernon, D. J. (2005). Can neurofeedback training enhance performance? An evaluation of the evidence with implications for future research. *Applied Psychophysiology and Biofeedback*, *30*(4), 347-364.

Weafer, J., Baggott, M. J., & de Wit, H. (2013). Test–retest reliability of behavioral measures of impulsive choice, impulsive action, and inattention. *Experimental and Clinical Psychopharmacology*, *21*(6), 475-481.

Wüst, S., Federenko, I. S., van Rossum, E. F., Koper, J. W., & Hellhammer, D. H. (2005). Habituation of cortisol responses to repeated psychosocial stress – further characterization and impact of genetic factors. *Psychoneuroendocrinology*, *30*(2), 199-211.

Ziółkowski, A., Graczyk, M., Strzałkowska, A., Wilczyńska, D., Włodarczyk, P., & Zarańska, B. (2012). Neuronal, cognitive and social indicators for the control of aggressive behaviors in sport. *Acta Neuropsychologica*, *10*(4), 537-546.

http://www.olympic.org/olympic-results/london-2012/rowing accessed on 13.02.2014.

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