Fugiel Jarosław, Wosik Grzegorz, Chromik Krystyna, Rohan Anna. Validity of a diagnostic instrument to measure fine motor coordination. Journal of Education, Health and Sport. 2018;8(9):527-537 eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1407475
http://ojs.ukw.edu.pl/index.php/johs/article/view/5886

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part b item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eissn 2391-8306 7

The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 02.08.2018. Revised: 18.08.2018. Accepted: 02.09.2018.

Validity of a diagnostic instrument to measure fine motor coordination

Jarosław Fugiel[1], Grzegorz Wosik[2], Krystyna Chromik[3], Anna Rohan[4]

[1]Division of Antropokinetics, University School of Physical Education in Wroclaw
[2]Institute for Health and Nutrition, Czestochowa University of Technology
[3]Division of Antropology, University School of Physical Education in Wroclaw
[4]Division of Anatomy, Medical University in Wroclaw

Abstract
The assessment and analysis of fine motor coordination is a difficult task due to the intrinsic complexity of psychomotor performance and its integration with cognitive functioning. The increasing use of electronics (e.g. computers, tablets, smartphones) in daily life has made fine motor skills increasingly important. The aim of this study was to test fine motor performance with two congruent diagnostic instruments, the Motor Performance Series work board and an enhanced version known as the Motor Coordination Analyzer for the Upper Extremity. A twenty-eight female 1st year university students completed a series of hand dexterity tasks (i.e. steadiness, line tracing, aiming, inserting pins, and tapping) using analogous test protocols on both devices. Moderate to strong correlations were obtained between the two instruments, suggesting that the device can also be used in the assessment of fine motor coordination.

Key words: motor coordination abilities, Motor Coordination Analyzer for the Upper Limbs, Vienna Test System

Streszczenie

Dobór metod do oceny koordynacyjnych zdolności motorycznych nie jest zadaniem łatwym. Wynika to z ich dużej złożoności, a w porównaniu do zdolności kondycyjnych z odmiennych uwarunkowań i charakteru wykonywanych czynności. W przypadku zdolności koordynacyjnych podłożem dla ich funkcji jest działanie ośrodkowego układu nerwowego. Równocześnie ze względu na powszechność urządzeń wykorzystywanych w codziennych czynnościach takich jak komputer, tablet czy smartfon koordynacyjne zdolności motoryczne ręki, nazywane też małą motoryką, nabierają coraz większego znaczenia.

W pracy porównywano wyniki testów diagnozujących koordynacyjne zdolności motoryczne ręki, które uzyskano przy użyciu Wiedeńskiego Systemu Testów i Analizatora AKZM-KG I.

Oceniano poziom szybkich i precyzyjnych czynności kończyn górnych dorosłych kobiet, z wykorzystaniem dwóch narządzi pomiarowych. W badaniach uczestniczyło 28 studentek. Do analizy wybrano następujące testy oceniające małą motorykę.

Stwierdzono, że wyniki uzyskane przy użyciu analizatora AKZM-KG I wykazują wysokie związki z wynikami Wiedeńskiego Systemu Testów. Urządzenie AKZM-KG I może być wykorzystywane do oceny koordynacyjnych zdolności motorycznych.

Słowa kluczowe: koordynacyjne zdolności motoryczne, Analizator AKZM-KG I, Wiedeński System Testów

Introduction

Among the various dimensions of human movement, coordination abilities when compared with fitness abilities are characterized by different bio motor constructs and define different aspects of movement execution. As such, different methods and diagnostic tools are required to quantify the dimensions of coordination. Coordination is based on a highly complex, multi-level series of processes interlaced with the central nervous system and the functioning of multiple receptors, effectors, and neurons. Coordination abilities facilitate a whole range of movements such as those requiring high accuracy and precision free of temporal constraints but also quick-response movements or those performed in highly variable spatial and temporal conditions or requiring significant repetition. Furthermore, coordination abilities can be categorized among whole-body movements (encompassing gross motor skills) or individual body segments such as the hands (involving fine motor skills) [1].

Besides the different ways coordination can be quantified, this ability is further modulated by age and individual skill level, further complicating the selection of an appropriate diagnostic tool. The advent of electronic- and computer-aided laboratory methods has allowed researchers to collect more accurate, reliable, and objective data on coordination abilities [2-5]. One common and widely recognized instrument is the Motor Performance Series (MPS) work board integrated with Vienna Test System software [6]. Initially used in psychology testing to measure fine motor performance for treatment control, the instrument has seen increasing use in physiological and sports-based research [7-18]. It has been standardized over time (1986–1999) and allows for valid and reliable assessments of a variety of fine motor abilities by factorizing hand–arm movement speed and accuracy via a series of fine motor tasks (i.e. hand steadiness, line tracing, aiming, inserting pins, and tapping). The MPS work board requires minimal familiarization and does not necessitate previous experience with computers.

An enhanced version of the MPS recently made available is the Motor Coordination Analyzer for the Upper Extremities (MCA-UE). Patented in Poland (#21082) [19], this multi-functional device also assesses upper extremity fine motor performance and coordination via an identical battery of tests including tapping (wrist and finger movement speed), aiming and inserting pins (arm–hand movement precision and speed), line tracing (hand movement accuracy), and steadiness (hand tremor). This device shows similar practicality and potential in a wide variety of healthy and patient populations in different age groups and therefore its use in varied populations should be investigated.

Study purpose

The aim of this study was to assess fine motor performance in adult females using the MCA-UE and compare the concurrent validity of the device with the MLS using an analogous test battery.

Material and methods

The study was performed in 2017 at the Biokinetics Laboratory of the University of Physical Education in Wrocław (PN-EN ISO 9001:2001 certified) and on-site at the Institute of Health and Nutrition of the Czestochowa University of Technology. A total of 33 females were initially recruited from a population of 1st year university students of which 28 met all eligibility criteria. These included any impairment that could functionally limit fine motor performance and involvement in professional or elite sport so as to prevent influencing the results by individuals with high levels of motor coordination. The final sample was aged 19.1–23.2 years (mean 21.5 years). All participants declared themselves to be unambiguous right-handers and provided their consent to participate in the study.

All testing was performed individually in an isolated, quiet room and each participant received standardized instruction on how to complete each test. Testing was performed on the MLS work board (Fig. 1) and then repeated on the MCA-UE device constructed on Czestochowa University of Technology. (Fig. 2–4) following the same order and procedures. The motor tasks selected from the MLS test battery were (WST 2004):

1) Tapping – measures the ability to perform fast, repetitive movements with the right and left hand; measured by the number of accurate taps performed within a time interval of 32 s.

2) Aiming – measures the ability to perform fast and accurate movements with the right and left hand by consecutively hitting 20 holes arranged linearly; measured by the total time needed to complete the task and by the number errors (missed holes).

3) Line tracing – measures the ability to perform fast and accurate movements with the right and left hand by tracing a grooved track with a stylus; measured by the total time required to complete the task and the number of errors (touching the sides or bottom of the track).

4) Steadiness – measures the ability to maintain a prescribed position with the right and left hand by inserting a stylus into a hole and holding it steadily for 32 s; measured by the number of errors (contacts made with work board).

5) Inserting pins – measures the ability to perform fast and repetitive movements with the fingers of the right and left hands by inserting 25 pins into a row of holes as fast as possible; measured by the total time needed for task completion.

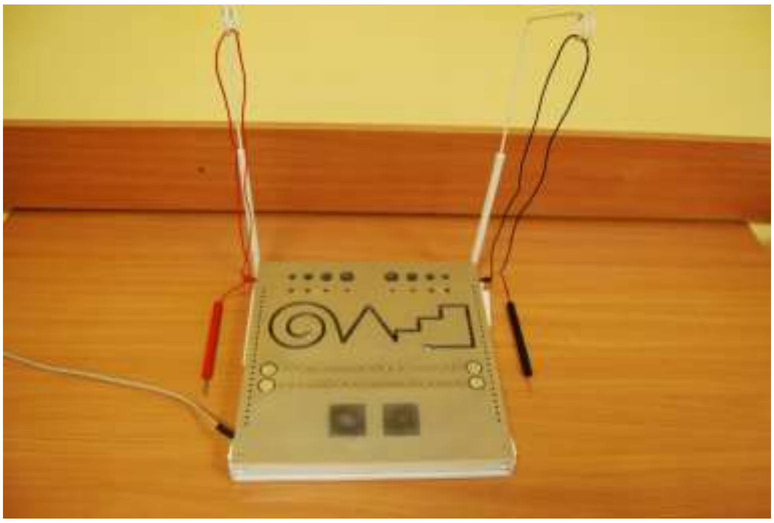

Figure 1. The MLS work board

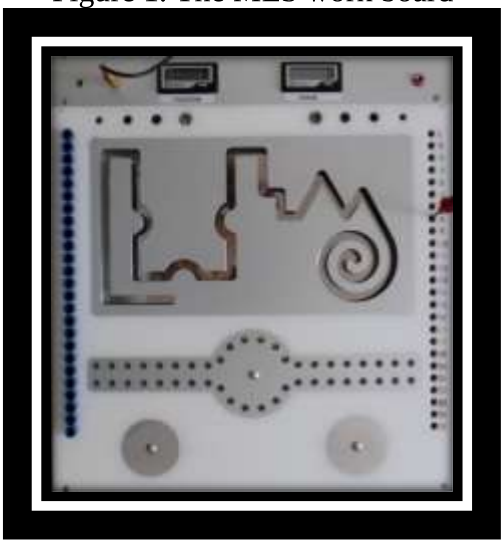

Figure 2. The MCA-UE work board

Figure 3. Version 'A' of the MCA-UE work board

Figure 4. MCA-UE stylus

The distribution of the data set was screened for normality using the Shapiro–Wilk test. Descriptive statistics (mean and standard deviation) were calculated for all test measures. Pearson's correlation coefficients (*r*) were used to assess the validity of the MCA-UE test results with the MLS. Following the thresholds outlined by Maining (1975), $1.00 \geq r \geq 0.85$ would indicate excellent validity, $0.85 > r \geq 0.80$ very strong validity, $0.80 > r \geq 0.75$ strong validity, $0.75 > r \geq 0.70$ good validity, $0.70 > r \geq 0.60$ satisfactory validity, $0.60 > r \geq 0.30$ moderate validity, and $0.30 > r$ denotes weak validity. Data processing was performed using the Statistica 13.1 software package (Statsoft, USA).

Results

Performance in the analogous MPS and MCA-UE tests is described in Table 1. The results of the linear correlation analyses between the MPS and MCA-UE variables are presented in Table 2. Stronger correlations were observed in the coordination measures of the MCA-UE that analyzed movement speed rather than movement accuracy and in the tapping and inserting pins tasks performed by the left and therefore non-dominant hand. Weak or no correlations for either right or left extremity were observed in the aiming and steadiness tasks.

The strongest relationship was observed in the test duration of the line tracing task, with significant correlations observed for both right (0.80) and left (0.81) extremity. The measure number of errors in this test showed significant moderate correlations between the MPS and MCA-UE and was stronger for the right extremity. Significant correlations were also observed in the tapping test (number of accurate taps), which were good for the left extremity (0.73) and moderate for the right extremity (0.48). In the inserting pins test, a significant moderate correlation was observed for the left extremity (0.50) and non-significant weak correlation for the right extremity. No significant correlations between the MPS and MCA-UE were observed among any of the measures in the aiming and steadiness tests. In the aiming test, the measure number of errors was weakly correlated for both the right (−0.26) and left (−0.22) extremity whereas the remaining test measures (aiming test duration and steadiness number of errors) showed no correlations for either right or left extremity.

Table 1. Performance measures in the MPS and MCA-UE tests

Task	Variable	Hand	MLS				MCA-UE			
			$\bar{x}$	sd	min	max	$\bar{x}$	sd	min	max
Tapping	*n* of taps [n]	Reight	207,8	29,6	169	250	202,8	21,58	169	268
		Left	183,2	24,3	151	248	179,4	21,29	153	222
Aiming	test duration [s]	Reight	7,34	1,40	5,28	9,76	12,37	2,71	6,94	22,00
		Left	7,83	1,61	4,84	10,48	13,91	3,47	8,31	23,91
	n of errors [n]	Reight	1,31	1,23	0	6	20,03	1,99	15	22
		Left	2,59	2,37	0	9	20,52	1,34	18	22
Line tracing	test duration [s]	Reight	28,30	11,90	7,07	54,94	32,63	10,53	19,13	59,69
		Left	28,75	14,32	9,01	66,88	36,51	14,48	21,90	67,94
	n of errors [n]	Reight	24,44	8,80	7	43	13,15	7,01	1	28
		Left	33,22	14,48	13	89	24,22	9,61	1	45
Inserting pins	test duration [s]	Reight	46,33	4,52	39,24	63,74	40,82	3,46	32,28	48,40
		Left	42,80	4,93	34,66	53,46	45,85	3,95	37,69	52,94
Steadiness	*n* of errors [n]	Reight	1,25	1,22	0	4	0,59	0,58	0	4
		Left	3,19	3,10	0	17	1,41	1,33	0	13

Table 2. Correlation analyses (Pearson's *r*) of MPS and MCA-UE measures

Task	Variable	MLS – MCA-UE	
		Right extremity	Left extremity
Tapping	*n* of taps	**0.48**	**0.73**
Aiming	test duration	−0.05	0.02
	n of errors	−0.26	−0.22
Line tracing	test duration	**0.80**	**0.81**
	n of errors	**0.60**	**0.46**
Inserting pins	test duration	0.26	**0.50**
Steadiness	*n* of errors	−0.01	−0.05

Discussion

In recent years, industrialized countries have seen a dramatic shift in lifestyle and physical activity level [20, 21]). Sedentary behavior, minimal exercise, and increased automation in many activities of daily living have reduced fitness. These changes have been observed across all age ranges from young children to older adults and may result in attenuated motor function including those fine motor skills [22, 23]. At the same time, young age is a time when fine motor performance is developed and enhanced in the dimensions of precision, speed, and accuracy. These fine motor skills are particularly important with the increasing use of different electronic devices including computers, tablets, and smartphones by ever younger age groups.

The changes in the type and frequency of daily motor activity require the selection of appropriate diagnostic instruments with high objectivity and accuracy that test for reliable coordination measures. An important consideration is that such an instrument should assess both motor development and performance across different age groups. In the case of measuring hand coordination skills, consideration should also be paid to the potential confounder of prior motor experience such as the frequent use of a computer. One device that is known to meet the aforementioned requirements and seen significant clinical application is the MPS of the Vienna Test System. It has been found to show high objectivity, accuracy, and reliability in the measure of hand dexterity and associated upper extremity fine motor skills although it has seen more use in psychomotor research and less in population-based research [2, 7, 24, 25]. In addition, the literature notes the use of other computer- and electronic-aided instruments in the assessment of motor coordination [5, 26, 27, 28, 29, 30]. One alternative to the MPS work board is the MCA-UE which applies an identical test battery assessing fine motor performance in the dimensions of movement speed and accuracy (including hand steadiness) with changing directions of movement but with certain modifications and improvements over the MPS. The aiming test was also performed in a straight line as in the MPS but included a circular component. Additionally, the participant had to properly insert the stylus into each hole and not just touch a contact field. A more significant change was introduced in the line tracing test, in which only one version of the grooved track is available in the MPS. When performed with the right hand this task involves an adduction movement but when performed with the left hand involves hand abduction. Hence, the this test measured a different movement structure that could further differentiate the results between left and right hand performance but also between individuals with opposite hand dominance. The MCA-UE was designed with two interchangeable versions of the track that were mirror images of each other and would therefore not differ when performed with the right or left hand. In addition, the device offers several other tracks with varying degrees of difficulty and can therefore be tailored to populations with or without impaired fine motor performance. The final test that was modified was the inserting pins task, in which the MCA-UE allows the use of various sized pins and pin holes compared with the use of one-size holes and reduced-diameter pins in the MPS.

This study recruited a sample of age-matched females with a relatively similar lifestyle (1st year university students not involved in professional or elite sport) in order to select a group of individuals that would share a similar motor profile. Borecki et al. [7] found that individuals who frequently play computer games obtained better results than similar cohorts in the motor coordination tests administered via the MPS. This ascendancy was also reported in other studies [31, 32].

The results of the present study showed moderate to strong correlations between the MPS and MCA-UE in the tapping, line tracing, and inserting pins tests or the tests that assess hand movement speed. No associations were observed between the two tests in the aiming and steadiness tests. In the aiming test, the task is to rapidly touch a row of brass holes with the work board stylus. However, as previously mentioned, the MPS holes were arranged in a row whereas the holes in the MCA-UE differed by introducing a circular element as well as using a different technique when inserting the stylus. In the steadiness test, while both tests followed an identical protocol, the MCA-UE stylus differed from the one used in the MPS which needed to be inserted into a hole with a different diameter. These differences in task layout or test procedures may explain the lack of correlation between the diagnostic tools in these two coordination domains.

Despite the similar characteristics of the two devices and analogous testing protocols, the two devices show certain differences among the analyzed motor tests. Each of the work boards has their own intrinsic advantages that future researchers need to consider when deciding on the most pertinent diagnostic instrument. The increasing use and importance of computer-aided methods in the assessment of fine motor coordination have given an impetus to tools of this nature. While the MPS under the Vienna Test System framework has been used for many years in research and clinical practice, it does possess certain limitations that were amended in the development of the MCA-UE. The results of the present study suggest that additional research is needed to standardize the MCA-UE and confirm its validity and reliability in a wider population.

Conclusions

Correlation analyses of the fine motor coordination tests revealed strong to moderate associations between the MPS and MCA-UE for those tests that assess hand movement speed whereas only weak or a lack of correlations were observed in the aiming and steadiness tests possibly explained by the difference in work board layout or testing protocol. The MCA-UE shows potential in the assessment of fine motor coordination particularly in the coordination domains of upper extremity movement speed and accuracy.

References

1. Fugiel J, Czajka K, Posłuszny P, Sławińska T. Motoryczność człowieka. Podstawowe zagadnienia z antropomotoryki. MedPharm, Wrocław. 2017.

2. Fugiel J. Zmienność rozwoju wybranych zdolności koordynacyjnych na tle budowy morfofunkcjonalnej dzieci i młodzieży z terenów przemysłowych. Studia i Monografie, AWF, Wrocław. 2014; 119.

3. Klocek T, Spieszny M, Szczepanik M. Komputerowe testy zdolności koordynacyjnych. Centralny Ośrodek Sportu, Warszawa. 2002.

4. Sterkowicz S, Jaworski J. Walidacja testów komputerowych mierzących wybrane koordynacyjne zdolności motoryczne. Wychowanie Fizyczne i Sport. 2006; 56, 1: 11–15.

5. Waśkiewicz Z, Juras G, Raczek J. Komputer1owa diagnostyka zdolności rytmizacyjnych. Rocznik Naukowy, AWF, Katowice. 1999; 27: 25–39.

6. Shuhfried GmbH-MLS. Motor Performance Series. http://www.schuhfried.com/vienna-test-system-vts/all-tests-from-a-z/test/mls-motor-performance-series/. Accessed 30 nov. 2017.

7. Borecki L, Tolstych K, Pokorski M. Computer games and fine motor skills. Adv Exp Med Biol, 2013; 755: 343–348.

8. Domaradzki J, Ignasiak Z. Zróżnicowanie płciowe wybranych predyspozycji koordynacyjnych dzieci w młodszym wieku szkolnym – wyniki Wiedeńskiego Systemu Testowego. Antropomotoryka. 2009; 45, 19: 3–9.

9. Gierczuk D, Sadowski J, Lyakh V. Rzetelność i informatywność diagnostyczna testów komputerowych służących do oceny koordynacyjnych zdolności motorycznych w zapasach. Antropomotoryka. 2008; 44, 18: 77–84.

10. Klasik A, Czech K. Wiedeński System Testów (Vienna Test System) jako narzędzie diagnozy procesów poznawczych człowieka. [W:] J.M. Stanik (red.) Zastosowanie wybranych technik diagnostycznych w psychologicznej praktyce klinicznej i sądowej. Wydawnictwo Uniwersytetu Śląskiego, Katowice. 2006; 294–317.

11. Kondraske GV, Potvin AR, Tourtellotte WW, Syndulko K. A computer – based system for automated quantification of neurologic function, IEEE Trans Biomed Eng, 1984; 31 (5): 401–414.

12. Łuczak A. Wiedeński System Testów w doborze osób do zawodów trudnych i niebezpiecznych. Centralny Instytut Ochrony Pracy – Państwowy Instytut Badawczy, Warszawa. 2005; 2: 18–21.

13. Mehlich R, Iskra J, Waśkiewicz Z. Możliwość wykorzystania wiedeńskiego systemu testowego w ocenie zdolności rytmizacji płotkarzy. Rozprawy Naukowe, AWF we Wrocławiu. 2007; 25(1): 119–124.

14. Sebastjan A, Skrzek A, Ignasiak Z, Sławińska T. Age-related changes in hand dominance and functional asymmetry in older adults. PloS One, 2017, 12, 5, 7DOI:10.1371/journal.pone.017784.

15. Sebastjan A, Dąbrowska G, Ignasiak Z, Żurek G. Ocena motoryki precyzyjnej ręki starszych kobiet o różnym poziomie aktywności fizycznej. Fizjoterapia. 2008; 16, 1: 41–45.
16. Smith SS, Kondraske GV. Computerized system for quantitative measurement of sensorimotor aspects of human performance. Phys Ther, 1987; 67(12): 1860–1867.
17. Turosz MA. Możliwość zastosowania wiedeńskiego systemu testów w diagnozie antycypacji czasowo-ruchowej sportowców. [W:] H. Sozański, K. Perkowski, D. Śledziewski. Kierunki doskonalenia treningu i walki sportowej. AWF, Warszawa, 2003; 161–164.
18. Ucińska M. Wiedeński System Testów – narzędzie pomocnicze w psychologicznych badaniach kierowców. Biuletyn Informacyjny Instytutu Transportu Samochodowego, Warszawa. 2008; 5(29): 4–10.
19. Wosik G, Głąbiński A. Świadectwo Rejestracji Wzoru Przemysłowego pt.: Aparat diagnostyczny do analizy deficytów motorycznych kończyn górnych, Nr 21082. Internetowy Portal Usługowy Urzędu Patentowego R.P., Biuletyn i Wiadomości Urzędu Patentowego R.P. Nr 12/2014.
20. Sulzenbruck S, Hegele M, Rinkenauer G, Heuer H. The death of handwriting: Secondary effects of frequent computer use on basic motor skills. Journal of Motor Behavior. 2011; 43(3): 247–251.
21. Zhang Y, Du G, Yang Y, Qin W, Li X, Zhang Q. Higher integrity of the motor and visual pathways in long-term video game players. Front Hum Neurosci. 2015; 9: 98.
22. Hastings EC, Karas TL, Winsler A, Way E, Madigan A, Tyler S. Young children's video/computer game use: Relations with school performance and behavior. Issues in Mental Health Nursing. 2009; 30(10): 638–649.
23. Weaver JB, Mays D, Weaver SS, Kannenberg W, Hopkins GL, Eroĝlu D, Bernhardt JM. Health-risk correlates of video-game playing among adults. American Journal of Preventive Medicine. 2009; 37(4): 299–305.
24. Olex-Zarychta D. Lateralizacja funkcjonalna kończyn człowieka i jej uwarunkowania w zakresie koordynacji motorycznej. AWF, Katowice, 2010.
25. Skrzek A, Pridalova M, Sebastjan A, Harasova D, Fugiel J, Ignasiak Z, Sławińska T, Rożek K. Fine motor skills of the hands in Polish and Czech female senior citizens from different backgrounds. Aging Clinical and Experimental Research. 2015; 27, 4: 491–498.
26. Avrunin OG, Selivanova KG, Husham Farouk Ismail S. A method of computer testing of the level of development of graphic skills, International Journal of Computer Science and Engineering. 2014; 3, 2: 19–26.
27. Jaworski J, Wieczorek T, Lyakh V. Własna propozycja zestawu testów komputerowych do pomiaru koordynacyjnych zdolności motorycznych. [W:] A. Kuder (red.) Proces doskonalenia treningu i walki sportowej. AWF Warszawa, IV. 2007; 29–32.
28. Juras G. Komputerowa ocena orientacji wzrokowej, [W:] J. Ślężyński (red.) Teoretyczne i praktyczne aspekty aktywności ruchowej człowieka. AWF, Katowice. 1996; 11–16.

29. Juras G, Juras B. Propozycja komputerowej oceny pamięci krótkiego czasu (STM). [W:] J. Ślężyński (red.) Efekty kształcenia i wychowania w kulturze fizycznej. AWF, Katowice. 1998; 54–58.
30. Sterkowicz S, Jaworski J. Ocena rzetelności własnego zestawu testów komputerowych do pomiaru wybranych koordynacyjnych zdolności motorycznych (badania pilotażowe). Antropomotoryka. 2006; 36: 81–90.
31. Blumen HM, Gopher D, Steinerman JR, Stern Y. Training cognitive control in older adults with the space fortress game: The role of training instructions and basic motor ability. Frontiers in Aging Neuroscience. 2010; 2: 145.
32. Boot WR, Kramer AF, Simons DJ, Fabiani M, Gratton G. The effects of video game playing on attention, memory, and executive control. Acta Psychologica. 2008; 129(3): 387–398.