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ЦЕНТР СПОРТИВНЫХ ИННОВАЦИОННЫХ ТЕХНОЛОГИЙ
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ПО ВОПРОСАМ СПОРТИВНОЙ НАУКИ В ДЕТСКО-ЮНОШЕСКОМ СПОРТЕ И СПОРТЕ ВЫСШИХ ДОСТИЖЕНИЙ

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COMPATIBILITY OF MEASURING SIMPLE REACTION TIME IN INDIVIDUALS USING COMPUTERIZED AND FINGERTIP VISUOMOTOR METHODS

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Many studies of the reaction time (RT) expressed this index as the interval between the time of signal detection and the beginning of motor response. Reaction time is widely used in various fields of science and practice: RT assessment is an important component of health science, developmental physiology, sports medicine and can increase the thoroughness of health and clinical examinations (Bernstein, 1967; Collins et al., 2003; Henneberg et al., 2001; Kolb & Whishaw, 1995; Lovell et al.,2001; Makdissi et al.,2001; Schendel & Robertson, 2002; Warden et al.,2001).

It is clear that impaired RT has functional relevance given that a rapid RT is necessary for injury avoidance and good professional skill performances. Reaction time assessment is an important component in sports medicine, especially for identification of brain concussion (Broglio & Guskiewicz, 2009; Collie et al.,2006; Collins et al.,2003).

There are 2 main tests that are useful to measure reaction time. The button push reaction time test measures how quickly a participant may click (push) a button. and the fingertip visuomotor test is a procedure for conducting a reaction time test using a ruler.

Advantages of computerized measurement of RT are: 1) that stimulus presentation duration is carefully controlled, 2) the period between stimuli may be easily randomized, and 3) that the time of response is easily measured (Eckner et al., 2010).

Despite the advantages of computerized neuropsychological testing, it has a limited role in practice especially on the playing field (Eckner et al., 2010). Reaction time assessment tools on a computer require specialized software and specific research skills that may limit its usage. The cost of computerized testing, at $669 to $677 per person, makes them unaffordable for many low profile athletes (Grindel, 2006).

It is obvious that the fingertip visuomotor field reaction time test is a very important method that is broadly used in athletic training clinics (Eckner et al., 2009; Eckner et al.,2010; Eckner & et al.,2011a,b,c).

Despite of broad usage of fingertip visuomotor tests measuring RT there is little available information comparing the computerized and fingertip visuomotor methods of determining RT. In other words, the existing literature doesn't answer the question; is the simple reaction time, tested using the simplified fingertip visuomoto method compatible with the results from the computerized methods in the same individual. We also did not find a clear answer to the question how compatible is fingertip visuomotor method selectively for the dominant and non dominant hands.

The purpose of our study was to determine the individual compatibility of the simplified fingertip visuomotor method of measuring simple RT selectively for the dominant and non-dominant hands of non-trained healthy young people of high school age.

Methods

Participants. The research began in December 2011 and was completed in January 2014. Initially research was carried out with 101 students of the 4th upper-secondary School in Biala Podlaska. (Polish Republic). The school was selected randomly. The research included all the girls (n=50) and boys (n=51) aged 17 years old (16.6 years+1 day – 17.5 years+29 days). None of the participants had outstanding athletic achievements. This age was selected because by this time the human motor system has mostly matured, especially in terms of anthropometrical maturation of the segments of the upper extremities (Malina, & Johnston, 1967). Besides, most of them do not at this time possess specific professional motor skills that may distort the results of the experiment.

Standard anthropometrical methods for measuring height and body mass were used (with accuracy ± 0.5cm and ± 0.1kg respectively). Using these data, the body mass index was calculated for each participant. All our selected participants had BMI from 18.5 to 25, placing them in the normal or healthy range as defined by the World Health Organization.

Reaction time was tested between 9 a.m. and 12 a.m. in the same conditions and using the same tools. Testing took place in an isolated room. In both tests, while performing the exercise, the participants were able to sit comfortably in a chair and were motivated to enhance their results as much as possible.

Computerized method of testing simple sensor motor reactions

The research was carried out in standardized testing conditions that have been broadly used by other researchers.(Ando et al., 2002; Barthélémy & Boulinguez, 2001; Kosinski & Cummings, 2004). The device has the CE trademark and the test assessing reaction time has a 10-year license.

Before testing, each subject was familiarized with the required procedures and then participated in a preliminary test to become acquainted with the equipment. The RT test that is part of the Vienna Test System (VTS) was used in the study (Gierczuk & Ljach, 2012). As soon as the stimulus was perceived by the participant, she or he would respond by pressing the response switch using her/his index finger. Participants were instructed to focus on a cross in the centre of the screen, and push the button as quickly as possible in response to visual signals (appearance of white light) started at random intervals (4–8 seconds) as previously recommended (Schmidt & Lee, 1999). Training before the experiment included reaction for 5 visual stimuli which were randomly distributed in time, immediately followed by 11 data acquisition trials. The study was performed for both dominant and subdominant hands.

Fingertip visuomotor measurement of simple RT using a ruler- RT fingertrip

The participant sat with the forearm resting on a horizontal desk or table surface with the hand positioned at the edge of the surface. The participant held out the chosen hand and extended the thumb and index finger so they were 2 cm apart, in order to maximally diminish the time of motion. An assistant held a metallic metric ruler with its end exactly even with the participant's extended thumb and index finger. The ruler was vertical with the lowest numbers near the participant's hand. Then the ruler was suddenly dropped, and the participant grasped it between the thumb and index finger as soon as possible. The experimenter recorded the distance the ruler fell

through the participant's fingers. Then the time it took for the participant to react and catch the falling ruler was calculated using the following formula:

$$t = \sqrt{\frac{d}{490 cm/s^2}}$$

Where: t is the reaction time, and,
d is the distance recorded in cm.

The examiner suspended the ruler and suddenly released it after randomly determined time delays between 4 and 8 seconds so as to minimize the participants' ability to anticipate release of the ruler. Each participant performed 2-4 practice trials, immediately followed by 11 data acquisition trials. The study was performed for both dominant and subdominant hands subsequently (Eckner et al., 2009, 2010). Anticipatory grasps and drop trials were excluded from the test.

Statistical analysis

All statistical analyses were conducted using SPSS for Windows (version 16.0; SPSS Inc, Chicago, IL). Means and SDs for $RT_{fingertip}$ and RT_{comp} were calculated for each participant. All individual $RT_{fingertip}$ were compared with all individual RT_{comp} in all participants using paired *t* tests. Reliability of the computerized and fingertip visuomotor tests was analysed using the one way ANOVA method. Point biserial coefficient of correlation (Glass & Stanley, 1970) was calculated separately for each participant between their 11 individual results for RT, received from the computerized (RT_{comp}) and fingertip visuomotor ($RT_{fingetip}$) methods.

Results

In both computerized and fingertip methods the RT values were significantly shorter from the right hand in males. There were no significant differences between males and females in both hands in both methods (see table 1). It is remarkable, the faster RT results appear in the fingertip visuomotor method in comparison to the computerized method.

Table 1. Results of reaction time (ms).

Method	Sex	Number of participants	Number of trials	Right		Left		Both		$P_{between}$ Left and Right
				Ave	SD	Ave	SD	Ave	SD	
Computerized method	Male	21	231	236	25	242	33	239	30	0.024
	Female	20	220	240	32	244	38	242	35	0.232
$P_{between\ genders}$				0.127		0.575		0.162		
Fingertip field method	Male	21	231	174	25	181	22	177	24	0.001
	Female	20	220	179	40	183	26	181	33	0.218
$P_{between\ genders}$				0.109		0.506		0.092		

One way ANOVA has shown a high level of reliability of results in all 11 trials for both methods for the left and right hands of both males and females (see Table 2).

Table 2. One way of analysis of variance; group stability of results in all 11 trials.

Method	Sex	Right		Left	
		M.S.R.	Significance	M.S.R.	Significance
Computerized method	Male	0.155	P>0.05	0.089	P>0.05
	Female	0.022	P>0.05	0.021	P>0.05
Fingertip field method	Male	0.236	P>0.05	0.433	P>0.05
	Female	0.200	P>0.05	0.238	P>0.05

Where: M.S.R. – mean square ratio. M.S.R. = Between 11 trials M.S./Residual M.S.

Individual point biserial coefficients of correlation between RT data obtained from both methods are presented in the Tables 3a and 3b.

Table 3(a). Point biserial coefficients of correlation between individual RT data in computerized and fingertip visuomotor tests in males (individual results).

	Right hand			Left Hand		
#	PBC	SE	t	PBC	SE	t
1	0.703	0.506	2.97	0.759	0.424	3.49
2	0.825	0.320	4.37	0.958	0.083	9.98
3	0.794	0.369	3.92	0.920	0.153	7.06
4	0.862	0.257	5.11	0.913	0.166	6.73
5	0.888	0.212	5.79	0.721	0.481	3.12
6	0.866	0.250	5.20	0.775	0.399	3.68
7	0.961	0.077	10.39	0.952	0.093	9.36
8	0.798	0.364	3.97	0.620	0.616	2.37
9	0.856	0.267	4.97	0.871	0.242	5.31
10	0.864	0.253	5.16	0.691	0.523	2.86
11	0.835	0.303	4.55	0.881	0.224	5.58
12	0.922	0.150	7.14	0.947	0.103	8.84
13	0.784	0.385	3.79	0.939	0.118	8.21
14	0.954	0.091	9.50	0.928	0.139	7.48
15	0.324	0.895	1.03	-0.495	0.755	-1.71
16	0.781	0.390	3.75	0.859	0.262	5.04
17	0.933	0.129	7.79	0.945	0.107	8.67
18	0.877	0.232	5.46	0.771	0.405	3.63
19	0.965	0.070	10.98	0.967	0.065	11.36
20	0.960	0.077	10.35	0.945	0.106	8.70
21	0.922	0.150	7.15	0.937	0.121	8.07

Where: SE - standard error. t - t criteria.

Table 3(b). Point biserial coefficients of correlation between individual RT data in computerized and fingertip visuomotor tests in females (individual results).

	Right hand			Left hand		
#	PBC	SE	t	PBC	SE	t
1	0.664	0.559	2.66	0.835	0.303	4.55
2	0.981	0.038	15.02	0.873	0.238	5.37
3	0.907	0.178	6.45	0.920	0.153	7.06
4	0.788	0.380	3.84	0.942	0.113	8.41
5	0.954	0.090	9.56	0.929	0.137	7.54
6	0.949	0.099	9.06	0.973	0.053	12.65
7	0.927	0.140	7.43	0.909	0.173	6.56
8	0.944	0.108	8.61	0.841	0.293	4.66
9	0.964	0.071	10.83	0.861	0.258	5.09
10	0.791	0.374	3.88	0.746	0.444	3.36
11	0.945	0.108	8.64	0.913	0.166	6.73
12	0.872	0.239	5.35	0.815	0.336	4.22
13	0.873	0.237	5.38	0.772	0.404	3.65
14	0.395	0.844	1.29	0.763	0.418	3.54
15	0.674	0.546	2.74	0.616	0.620	2.35
16	0.413	0.829	1.36	0.924	0.146	7.26
17	0.766	0.413	3.58	0.964	0.071	10.85
18	-0.198	0.961	-0.61	-0.546	0.702	-1.95
19	0.708	0.499	3.00	0.934	0.128	7.84
20	0.667	0.555	2.69	0.792	0.373	3.89

Where: SE - standard error.
t - t criteria.

Note however, a small number of participants (1 boy and 3 girls) have low values of coefficient of correlation and some participants even have a negative value of these coefficients from both hands.

Discussion

The purpose of our study was to identify compatibility between RT returned by both methods of testing, the fingertip visuomotor ($RT_{fingertip}$) and computerized (RT_{comp}), for individual participants. We have recorded shorter values of RT in the fingertip visuomotor method in comparison to the computerized method. We can explain this fact by different effectors and different motor units deployed in these different methods, as well as different sensory receptors and pathways engaged in this process. In the computerized method the stimulus is the switching on of a light, in the simplified field method it is the beginning of movement of the ruler. The same patterns

have been recorded by other researchers (Eckner et al, 2010, 2011a, b). We used a shorter distance between the fingers of participants than has been recommended, to diminish the time of motion. This factor alone can diminish the total time of sensor-motor reactions.

Using the one way ANOVA method we found a very small difference between trials using each method of testing reaction time. There is thus a high level of reliability related to both methods of measuring of RT for both hands and for both sexes. This finding means that the reliability of both the computerized and fingertip visuomotor tests was high.

Individual compatibility between the two tests was high for the vast majority of people demonstrating a high level of point biserial coefficient of correlation. It is clear from the fingertip visuomotor method that the sex of the participant affects all reaction time baseline data, but does not reach the level of significance possibly due to sample size. Other studies have also showed non-significant differences in reaction times between males and females. This finding is consistent with the observation of other workers (Mishra et al., 1985; Nikam & Gadkari, 2012; Shenvi & Balasubramanian, 1994). Other researchers have however demonstrated contradictory results (Der & Deary, 2006; Soto-Rey et. al., 2014).

Conclusion

The fingertip visuomotor method of measuring simple reaction time gives a good indication for the results that would be obtained from the push button computerized method. Like the computerized method of measuring RT, the fingertip method is highly reliable. However, for a small number of participants the compatibility between the two methods of testing was not high. We can speculate that this fact may be due to more expressed emotional reactions of females, in comparison to males as was documented in specific research by Birditt and Fingerman (2003). Future research should include self-report assessment in addition to assessments of the RT in order to fully understand obtained sex differences in the case of individual incompatibility between the fingertip visuomotor and computerized method of measuring RT. We also recommend that examiners who use the fingertip visuomotor method of measuring reaction time in girls carefully control the distance between fingers.

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