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## Effects of ipsilateral and crossed eye-hand dominance on catching performance in prepubescents

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### Abstract

This study investigates the effects of ipsilateral and crossed hand-eye dominance on one and both hands catching performance (OHCP and BHCP) in participants aged 10 to 13 years. The combined groups including hand and eye dominance consisted of right handed-right eyed (RHRE), right handed-left eyed (RHLE), left handed-left eyed (LHLE) and left handed-right eyed (LHRE), respectively. In this study the mean values were only higher in the favor of LHLE females in left hand OHCP from 2 and 3 m distances. In other side, LHLE males had a higher mean values not only in left hand OHCP from 2 and 3 meters but also in the right hand OHCP from 3 meters. No significant difference was observed in BHCP among four groups in both genders. In conclusion, ipsilateral hand-eye dominance is an advantage for OHCP compared to cross dominance. Also left side had an advantage compare to the right side in OHCP.

Keywords: Hand dominance; physical activity; gender.

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## 1. Introduction

The Ball catching is a challenging and complex motor skill that needs to be set the strength of the hands and the timing ability of movement according to the speed, distance, weight and size of the ball (Peper, Bootsma, Mestre & Bakker, 1994). It is generally defined as the controlled reduction of the speed of an airborne projectile (Chapman, 2008). The function of eyes in catching is an important factor in gathering sensory information. Then the visual information is interpreted and integrated by the brain with other sensory information, and finally it sends out appropriate motor signals to the muscles (Zupan, Arata, Wile & Parker, 2006). Catching skill that used in many sports including handball, basketball, baseball and soccer for goalkeeper can be defined as the ability to catch moving object with the hands while the elbow is being bent in the same direction, moving rapidly or the ball is being caught with one or two hands in front of your chest. In the implementation of this fundamental movement skill; the following steps are executed; 1) during the preparatory phase, the hands are on the front of the chest and elbows with flexed position, 2) arms and hands extend to catch the ball and 3) the ball caught just with the hands (Department of Education, 1999). To be successful in interceptive movements including catching or hitting the ball, person's movement behavior should be providing a very precise alignment for spatio-temporal character of the movement (Peper et al. 1994). The catching with one or two hands needs the coordination of hand and eyes as result of interacting visual and motor systems (Dirksen, De Lussanet, Zentgraf, Slupinski & Wagner, 2016).

Predictive visual information related to the space-time behavior of critical factors in catching performance. In this task, eye-hand coordination involves the integration of the eyes and the hand or hands as a unit. Any deficiency in this ability can result in a decrease in catching performance in sports like rugby, basketball, handball and baseball. In this manner, the catching performance should be analyzed according to the type of hand and eye dominance. It can be proposed that the location of hand and eye dominance in same side or opposite side may have an advantage on one or two arm catching performance in prepubertal males and females. Depending on motor and sport performance differences related laterality were only reported for one limb like hand, foot and eye (Tan, Akgun & Teletar, 1993; Ziyagil, Gursoy, Dane & Yuksel, 2010; Tran & Voracek, 2016). This study aims to investigate whether there is a significant difference related to the combination of handedness and eyedness in catching performance. Thus, the purpose of this study was to investigate the effects of same and crossed hand-eye dominance on OHCP and BHCP in prepubertal males and females according to their eye and hand preferences.

## 2. Material and Method

Data were collected from the total of 139 participants engaging physical and sports activities including 73 male and 66 female secondary school students aged 10 to 13 years. After selecting all left handed participants, right handers were randomly selected from the secondary school students. Of the male participants, 30.1% were left-handed while 69.9% were right-handed. Of female participants, 34.8% were left handed while 65.2% were right handed. In male and female groups, 43.8% and 34.8% were left-eyed and 56.2% and 65.2% were right-eyed, respectively. The combined groups including hand and eye dominance consisted of right handed-right eyed (RHRE), right handed-left eyed (RHLE), left handed-left eyed (LHLE) and left handed-right eyed (LHRE), respectively. In males, there were 11 RHRE (15.1%), 30 RHLE (41.1%), 12 LHLE (16.4%) and 20 LHRE (27.4%) participants, respectively. In females, there were 12 RHRE (18.2%), 31 RHLE (47.0%), 11 LHLE (16.7%) and 12 LHRE (18.2%) respectively. All participants presented normal motor function and without any neurological or motor disorders suspected. No participant has had any medical condition or disability that limited participation in physical activity. Informed consent form signed by the entire participant and their parents prior to the study. They gave their informed consent for the experimental procedure as required by the Helsinki declaration.

Hand preference was assessed the means of the “Edinburgh Handedness Inventory” which generates scores ranging from 100 to -100. Participants were classified as right handed (scores from 0 to 100) and left handed (scores from -100 to 0) (Oldfield, 1971; Tan, 1988).

Eye preference was determined by extending arms forward and form opening between the hands. In this test, participants were asked to sit with arms stretched out and parallel manner to the body, 25x15 cm in size and 3 cm in diameter in the middle of the card shown across the gap "A" bring the center of the card and the card will face closer towards removing the image (Cheng, Yen, Lin, Hsia, Hsu, 2004).Opening will be aligned with the dominant eye (Walls, 1951; Cheng et al. 2004).

Before the start of the ball catching test, the child was allowed to bounce and catch the ball five times to become familiar with the bouncing and catching tasks. *Ball catching ability* test consisted of eight series of 10 consecutive trials. The tester had to throw the ball underarm into the hand(s) of the child. A catch was considered to be a failure if the child missed the ball or caught it against the body. The total score ranged between 0 and 80 points. (Waelvelde, Weerdt, Cock & Engelsman, 2003). et al. 2009). Tester throws the ball from a height of between waist and shoulder to the way to catch at the child’s chest level. If ball comes out at waist level and shoulder height was not considered as a valid attempt. A minimal amount of training was required for testers to be able to throw the ball smoothly and consistently to the child. Progressions in the degree of difficulty were obtained by catching the ball with both hands, then one hand, and by increasing the distance. The number of correctly executed catches was recorded as a catching scores (Waelvelde, Weerdt, Cock & Engelsman, 2003).

After performing normality tests, Kruskal Wallis tests were used for comparison among four groups. Mann Whitney U test was also used for two group comparisons.

### 3. Results

There were no significant differences in physical characteristics among RHRE, RHLE, LHLE and LHRE groups in both genders (Table 1). In Males, significant differences were observed among hand-eye dominance groups in mean values of left hand one hand catching from 2 and 3 meters, and right hand catching from 3 meters. Male LHLE participants had also significantly highest mean value in these three parameters. Difference in the favor of male LHLE group was not significant in right hand catching performance from 2 meters. In both hands catching from 2 and 3 meters, differences were not significant but LHRE had a higher than other groups (Table 2). In females, significant differences were observed among hand-eye dominance groups in mean values of left hand catching from 2 and 3 m. Female LHLE participants had also significantly highest mean value in these three parameters. Differences in the favor of female LHLE were not significant in right hand catching performance from 2 m and 3 m. Difference in the favor of male LHLE was not significant in right hand catching performance from 2 meters. In both hands catching from 2 and 3 meters, differences were not significant but LHLE group had a higher than other groups (Table 3).

**Table 1. Comparison of physical characteristics in males and females with respect to their hand and eye dominance groups.**

Genders>		M A L E S							F E M A L E S						
Variables	Hand-eye dominance	N	M	SD	Min.	Max.	X <sup>2</sup>	Sig	N	M	SD	Min.	Max.	X <sup>2</sup>	Sig
Age (Years)	RHRE	11	11,36	1,03	10,00	13,00	5,064	,167	12	11,92	1,08	10,00	13,00	3	3,568
	RHLE	30	11,73	0,94	10,00	13,00			31	11,87	0,92	10,00	13,00		

	<b>LHLE</b>	12	11,67	0,78	11,00	13,00			11	12,27	0,90	11,00	13,00		
	<b>LHRE</b>	20	12,10	1,12	10,00	13,00			12	11,58	0,90	10,00	13,00		
	<b>Total</b>	73	11,77	0,99	10,00	13,00			66	11,89	0,95	10,00	13,00		
	<b>RHRE</b>	11	145,72	8,18	132,00	160,40			12	151,27	9,83	133,00	165,00		
Body	<b>RHLE</b>	30	149,47	11,35	131,40	178,00			31	151,37	8,96	132,00	169,00		
Height	<b>LHLE</b>	12	148,23	10,30	137,00	170,00	4,516	,211	11	152,42	8,32	139,00	167,00	3	2,930
(cm)	<b>LHRE</b>	20	154,18	11,59	135,50	171,00			12	147,50	6,49	137,00	161,50		
	<b>Total</b>	73	149,99	11,01	131,40	178,00			66	150,82	8,59	132,00	169,00		
	<b>RHRE</b>	11	39,44	6,88	27,50	53,10			12	41,58	9,10	27,90	53,90		
Body	<b>RHLE</b>	30	42,57	10,07	27,20	60,60			31	42,64	9,87	25,90	69,30		
Weight	<b>LHLE</b>	12	41,83	9,55	27,50	57,50	1,290	,732	11	45,94	7,48	32,30	61,90	3	3,037
(kg)	<b>LHRE</b>	20	44,44	11,70	25,90	65,00			12	39,78	9,66	27,90	56,70		
	<b>Total</b>	73	42,49	10,00	25,90	65,00			66	42,48	9,32	25,90	69,30		
	<b>RHRE</b>	11	18,49	2,21	14,34	22,57			12	18,01	2,66	14,95	23,60		
Body	<b>RHLE</b>	30	18,85	2,92	14,87	25,65			31	18,38	2,63	13,94	26,24		
Mass	<b>LHLE</b>	12	18,89	3,13	14,44	23,60	1,022	,796	11	19,73	2,42	15,10	23,30	3	3,478
Indeks	<b>LHRE</b>	20	18,50	3,72	13,90	26,44			12	18,10	3,29	14,22	24,22		
(BMI)	<b>Total</b>	73	18,71	3,05	13,90	26,44			66	18,49	2,73	13,94	26,24		

RHRE=Right Handed-Right Eyed, RHLE= Right Handed-Left Eyed, LHLE=Left Handed-Left Eyed, LHRE= Left Handed-Right Eyed, \*The was no significant difference between groups in both genders.

**Table 2. One hand and two hand catching performance of prepubertal males with respect to their hand and eye dominance.**

Variables	HEDG	N	M	SD	Min.	Max.	df	X <sup>2</sup>	Sig	Summary of Mann Whitney U
Right Hand Catching (2m)	RHRE	11	7,55	1,97	3,00	10,00				
	RHLE	30	6,90	2,78	,00	10,00				
	LHLE	12	8,33	0,98	7,00	10,00	3	3,477	,324	N.D.
	LHRE	20	7,95	2,58	,00	10,00				
	Total	73	7,52	2,43	,00	10,00				
Left Hand Catching (2 m)	RHRE	11	8,09	1,64	5,00	10,00				
	RHLE	30	6,67	3,06	,00	10,00				
	LHLE	12	9,25	1,22	6,00	10,00	3	9,885	,020*	LHLE >RHRE, RHLE;
	LHRE	20	8,05	2,46	1,00	10,00				
	Total	73	7,68	2,62	,00	10,00				
Right Hand Catching (3 m)	RHRE	11	7,55	1,29	6,00	9,00				
	RHLE	30	7,70	2,60	1,00	10,00				
	LHLE	12	9,00	1,21	6,00	10,00	3	5,728	,126	LHLE >RHRE,
	LHRE	20	7,75	2,05	3,00	10,00				
	Total	73	7,90	2,13	1,00	10,00				
Left Hand	RHRE	11	8,55	1,92	5,00	10,00	3	17,127	,001**	RHRE>RHLE;



		LHRE	12	7,83	1,85	5,00	10,00	RHRE>LHRE		
<b>Total</b>		66	8,36	2,03	,00	10,00				
<b>RHRE</b>		12	8,92	1,31	6,00	10,00				
<b>Both Catching (2 m)</b>	<b>Hands RHLE</b>	31	8,94	1,57	3,00	10,00				
	<b>LHLE</b>	11	9,18	0,98	7,00	10,00	3	,612	,894	N.D.
	<b>LHRE</b>	12	8,92	1,16	6,00	10,00				
	<b>Total</b>	66	8,97	1,35	3,00	10,00				
	<b>RHRE</b>	12	9,25	0,87	8,00	10,00				
<b>Both Catching (3 m)</b>	<b>Hands RHLE</b>	31	9,00	1,18	5,00	10,00				
	<b>LHLE</b>	11	9,36	0,67	8,00	10,00	3	,521	,914	N.D.
	<b>LHRE</b>	12	9,08	1,31	6,00	10,00				
	<b>Total</b>	66	9,12	1,07	5,00	10,00				
	<b>RHRE</b>	12	9,25	0,87	8,00	10,00				

\* p< .05, \*\* p<.01. HEDG=Hand Eye Dominance Groups. RHRE=Right Handed-Right Eyed, RHLE= Right Handed-Left Eyed, LHLE=Left Handed-Left Eyed, LHRE= Left Handed-Right Eyed, ND=No difference among groups.

#### 4. Discussion

For analyzing hand-eye coordination in catching skill, a new way of grouping as a mixture of hand and eye dominance was used. These were right handed-right eyed (RHRE), right handed-left eyed (RHLE), left handed-left eyed (LHLE) and left handed-right eyed (LHRE), respectively.

Results of this study showed that there were no significant differences in physical characteristics among RHRE, RHLE, LHLE and LHRE groups in both genders. These were matched for age and physical characteristics, as these might affect catching performance in males and females. Participants' catching performance was measured by one and two hand catching tests. Male LHLE participants had also significantly highest mean value in mean values of left hand one hand catching from 2 and 3 meters, and right hand catching from 3 meters. The superiority of male LHLE group is observable in OHCP not both hands catching performance. Female LHLE participants had also significantly highest mean value in mean values of left hand one hand catching from 2 and 3 meters, and right hand catching from 3 meters. No significant difference was observed among hand-eye dominance groups in both hands catching performance. Similar to our study, many studies reported that limb and organs depending hemispheric dominance can perform superior skills than the other limbs and organs (Ziyagil, Gursoy, Dane & Yuksel, 2010; Loffing, Hagemann & Strauss, 2012). In contrary, hand and foot dominance is thought to be related to the dominance of one cerebral hemisphere in the brain, but ocular dominance cannot be created in this way. A semi-decussation of optic nerve fibers at the optic chiasm means that visual information from the right and left eyes are represented in both hemispheres (Pointer, 2001; Laby & Kirschen, 2011).

Predictive visual information related to the space-time behavior of critical factors in catching performance. In this task, eye-hand coordination involves the integration of the eyes and the hand or hands as a unit. Any deficiency in this ability can result in a decrease in catching performance in sports like rugby, basketball, handball and baseball. In this manner, the catching performance was analyzed according to the type of hand and eye dominance in this study. It can be considered that the location of hand and eye dominance in same side may have an advantage on one hand catching performance in prepubertal males and females.

Spence and Flynn (2001) reported that the right hemisphere of the brain was generally associated with spontaneous and automatic responses, while the left hemisphere was mostly responsible for logical, controlled, and deliberate thoughts and actions: performing after planning. In the one hand

catching the performer with his/her timing ability must pay attention against to environmental factors to control the speed of the ball after releasing ball by opponent or teammate in unexpected time. From this point of view, one hand catching performance in this study is as an externally paced and open skill would be better in left-handers: though the mechanisms to explain the advantage of the left eyedness in catching performance are not clear. It seems to be possible the right hemisphere specialization for spatio-temporal and attentional processes is related to the left handedness (Dane & Erzurumluoglu, 2003; Gursoy, 2008). Coren and Porac (2014) reported that the speed of visual processing in the sighting dominant eye was approximately 14 msec faster than the information from the non-sighting eye. Money (1972) also found that higher perception accuracy by the dominant eye in the situations requiring fast motor control (Money, 1972). Although the mechanisms explaining the perceptual differences between the sighting and the non-sighting is unknown at present, current researches showed that better recognition and more rapid processing of the sighting eye can partly explain the difference in processing speed or afferent latency between the two eyes as a function of sighting dominance (Money, 1972; Porac & Coren, 1979, Sampson & Spong, 1961). Similarly, Tan (1993) concluded that sensory nerve conduction velocities are higher on the left than the right hand. Gupta, Sanyal and Babbar (2008), stated that sensory conduction velocity in both right and left median nerve was significantly higher in left handers as compared with right handers.

The performance differences in one hand catching among eye-hand coordination groups can be due to the speed of visual processing in the sighting dominant eye and higher sensory nerve conduction velocities and superior spatio-motor skills in left handers. In addition the study of Dane and Erzurumluoglu (2003) showed that the visual reaction time of the left eye and left hand in left handed males and females were significantly shorter than that of right handers. They concluded that left-handed players have probably an intrinsic neurological advantage. This superiority may be partly explain the higher one hand catching performance of LHLE group for both genders compare to other eye-hand coordination groups in this study.

It can be concluded that the one hand catching performance become higher in ipsilateral hand-eye dominance compared to crossed dominance. Also left side ipsilateral dominance had an advantage compare to the right side in one hand catching. So the superior catching ability of LHLE may be influenced by better dynamic visual acuity skills and sport-specific experience.

Further research is required to assess whether the ipsi and crossed laterality associated with one or two hands catching, can influence athletes' performance in many sports including handball, basketball, baseball and soccer for goalkeeper at junior and senior levels in both genders.

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