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ORIGINAL ARTICLE

VISUAL REACTION TIME AND VISUAL ANTICIPATION TIME BETWEEN ATHLETES AND NON-ATHLETES

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ABSTRACT

An experimental investigation was conducted to explore visual reaction time and visual anticipation time between athletes and non-athletes. These visual perceptual skills form the base for cognitive processes required by the brain to respond instantaneously to a stimulus. A total of 228 adolescents, equally distributed between athletes and non-athletes, aged 13 to 16 years (mean age 14.69 ± 0.99 years) were examined. The visual reaction time and visual anticipation time were measured using a Lafayette Reaction Timer (Model 63035) and Bassin Anticipation Timer (Model 35575) respectively. The visual reaction time results revealed that athletes have faster reaction time scores as compared to non-athletes, whereas with visual anticipation time, athletes had fewer errors and a higher consistency compared to non-athletes. There was, however, no interaction between gender and sports participation noted for both these visual perceptual skills. These research findings indicate that gender was not an obstacle in sports participation, therefore not limiting the potential to excel in sports performance. Knowledge gained from these research findings will benefit the sports industry, specifically in athletic and sports training as well as provide a basis for the identification of an individual's potential in their sports.

***Keywords**: athletes, non-athletes, sports, visual anticipation time, visual reaction time*

INTRODUCTION

Sports that involve a dynamic environment typically require high perceptual abilities for athletes to execute motor skills proficiently[1]. Research indicates that visual motor-response can be improved through training and this is shown through the positive impact of training observed during sports performance. The physiological limitations encountered by athletes during sports may also be overcome through the attainment of higher perceptual abilities[2,3]. The higher order perceptual abilities commonly known to have a significant impact on athletes are the visual reaction time and visual anticipation time.

Visual reaction time amongst athletes is mainly concerned with how fast an athlete reacts to a visual stimulus. Previous researchers defined visual reaction time as the interval between the sudden presentation of a stimulus and the beginning of the motor action response, measured in milliseconds (ms)[4]. Visual reaction time (VRT) can be measured as either 'simple visual reaction time' (SRT) and 'multiple-choice visual reaction time' (CRT). SRT is the time required for a subject to respond to the presence of a single stimulus while for CRT, it is the response to a multiple stimuli situation.

Research by Akarsu *et al*. evaluated the differences in measurement of visual reaction time between athletes and non-athletes[5]. Their research findings established that athletes had faster eye-hand visual reaction times over non-athletes. Furthermore, analysis of gender influence on athletes' visual reaction time by previous studies[6,7] found faster visual reaction time responses in male as compared to female athletes. However, other studies did not support the notion that gender was a factor that could influence differences in visual reaction time[2,5].

The second visual perceptual skill crucial for excellence in sports performance is visual anticipation time. Accurate visual anticipation timing plays a vital role in most sports that require dynamic responses from an athlete such as catching and hitting a ball or target. Anticipation time is generally defined as the ability to predict when an object or image would arrive at a designated target point in time and space[8]. Thus, visual anticipation timing is used to test eye-hand coordination as well as anticipation in visual accuracy. This perceptual ability has been speculated as a major factor contributing to successful performance in sports[9,10].

While almost anyone is capable of catching or hitting a ball, the factor that sets apart an athlete from the non-athlete is the ability to accurately hit a ball at the desired target in the opponent's court or table. Many studies have shown that there is faster and more accurate visual anticipation times obtained from expert athletes as compared to novice sportspersons[11-13]. The superior performance in visual anticipation time of some athletes may have been the result of continuous training as well as their greater involvement and participation in sports compared to a layperson. Thus, a person possessing better visual anticipation timing would have the ability for better achievements in sports and thus supports the use of this perceptual ability for talent identification[14].

So far, there has been little discussion about visual anticipation ability between athletes and non-athletes. Brady reported better anticipation ability among athletes compared to non-athletes[15]. The research that has been done to date tends to focus on the effects of gender on visual anticipation ability in the general population. However, these studies have shown controversial findings regarding gender differences in anticipation timing where some researchers found that males outperformed females[15-17] while others found it otherwise[18-20].

Taken together, these studies highlighted the importance to compare visual reaction time and visual reaction time differences with respect to both gender and level of sports participation while also comparing between athletes and non-athletes.

METHODS

Subjects

This was a cross-sectional study with 228 participants; attaining a power of 95% and an alpha level of 0.05 in a two-sided test as described by Erdfelder *et al.*[21]. Secondary students, aged between 13 to 16 years (mean age 14.69 ± 0.99 years) were recruited into this study. The participants with more than 5 years of experience in intensive sports participation were included in the study as athletes while non-athletes have no experience in intensive sports. The athletes and non-athletes were age-matched. The athletes in this study were from various sports discipline such as football, basketball, badminton, hockey, squash, and volleyball. Participants with colour vision defect and ocular disease were excluded from the study.

The aim of this study was explained to each participant and their guardians prior to data collection. Written consent was obtained before commencement of the study. This study complied with the tenets of the Declaration of Helsinki for research on human subjects and received approval from the Research and Ethics Committee for Medical Research of National University of Malaysia (UKM) (Approval code: UKM 1.5.3.5/244/NN-081-2013).

Apparatus

The visual reaction time measurement employed the use of three different tests namely the Simple Reaction Time (SRT) test; 2 Choice Reaction Time (2CRT) test, and 4 Choice Reaction Time (4CRT) test. The difference between each of these tests was the number of LEDs on the instrument that were initiated during each test procedure. During the test, subjects stood in front of the response panel and would be in a standby posture prior to stimulus initiation. As soon as the visual stimulus was initiated, the subject was to respond immediately to the presented visual stimulus by pressing the appropriate response button. The response time recorded was displayed on the instrument's electronic timer in unit millisecond (ms). The protocol used for visual reaction time measurement in this study followed the standard guidelines as described in the Visual Choice Reaction Time Apparatus User's Manual (Model 63035A) and Multifunction Timer/Counter User's Manual (Model 54035A) that were provided with the instruments used in this study.

Visual anticipation time was measured using a Bassin Anticipation Timer device (Lafayette Instrument Co., Model 35575) as it has been found to be an effective assessment instrument for comparing sports performance between males and females[22]. The reliability of the Bassin anticipation timer at various stimulus velocities has been validated by Nettleton and Smith and has been commonly used in many studies relating to anticipation timing accuracy studies[12,24-26]. This study utilized the Bassin anticipation timer with three 16-LED lamp runways attached together and mounted on a table top. The apparatus works by presenting a moving stimulus through a series of LED bulbs that are lit sequentially on a runway. Subjects are required to depress the handheld response button to coincide with the arrival of the moving lights at a target with differing speeds. The direction (early or late) of error after each trial was recorded in unit ms with a digital timer connected to the apparatus.

Procedure

The visual reaction time measurement consisted of three different tests performed by each subject namely the SRT, 2CRT and 4CRT tests. The difference between these measurements was the number of LEDs initiated during each procedure. The SRT test only required the subject to respond to one coloured LED using their right hand initially and followed by their left hand. Their hand dominance was noted based on their handedness while writing. The 2CRT test employed similar instructions. However, instead of a one choice reaction response, the subject is to respond to two coloured visual stimuli, namely white and red LEDs. The white and red LEDs are randomly stimulated one at a time. The same procedure is employed for the 4CRT test. Here, instead of two stimuli, the examiner will randomly twist the dial towards four different coloured stimuli (white, red, blue or green) to which the subject is to respond.

The visual anticipation timing is measured at different stimulus velocities, which are set at 5, 10, and 15 miles per hour (mph) {8, 16, and 24 kilometers per hour (kph)}[7], i.e., low, moderate and high velocity respectively. The testing is conducted at different stimulus velocities to simulate the actual speed of a ball played in different sports as testing at a constant speed does not represent the actual scenario encountered during sports play. Subjects are asked to anticipate the LED light reaching the target by pressing a button with the thumb of their preferred writing hand (dominant hand) to coincide with the arrival of light at the target. Prior to doing the actual test, subjects are given 5 practice trials to familiarize themselves with the test setup and procedure. Standardized instructions regarding the general nature of the study are provided to each subject prior to their practice trials.

Data Analysis

The mean visual reaction time scores and mean errors for visual anticipation time were calculated based on the data obtained from the tests. The number of repeated measurements taken for visual reaction time were five, ten and twelve times respectively for the SRT, 2CRT and 4CRT tests. Subsequently, the visual reaction time was averaged for each test. For visual anticipation time measurement, the absolute error (AE) represented the accuracy of response or magnitude of error while variable error (VE) characterized the consistency of response[10,27]. The mean error responses were recorded as positive when the response was late and negative when the response was early.

Mean visual reaction time scores and mean errors between the athletes, and non-athletes as well as between the three stimulus speeds were compared using independent *t*-test and Cohen's effect size (ES) [28]. The effect size of 0.20, 0.50, and 0.80 were considered as small, moderate, and large respectively. A two-way analysis of variance was performed to test the main effects of group and gender on visual reaction time and visual anticipation time mean scores. All data were reported as mean ± SD and statistical significance were set at $p < 0.05$. All statistical calculations were performed using SPSS for Windows (IBM SPSS version 22; SPSS Inc., Chicago Il, USA) software.

RESULTS

In total, 228 secondary students were enrolled in this study. The subjects were equally distributed between athletes (55 males, 59 females) and non-athletes (50 males, 64 females). The athletes had an average of 5.81 ± 2.67 years of experience in sports participation while non-athletes had no prior experience in intensive sports participation other than school physical education exercises. All subjects had good static visual acuity, equal to or better than 0.1 logMAR (equivalent to 6/7.5 Snellen chart notation) with no colour vision deficiency and were free from ocular disease as well as systemic illness. Refractive errors were corrected to best possible visual acuity before conducting the assessment.

Data analysis indicated significant findings for all visual reaction times measured ($p < 0.05$) and were compared between athletes and non-athletes (Table 1). A statistical comparison found that non-athletes displayed a delay in visual reaction time response as compared to athletes. However, the influence of sports participation and gender towards visual reaction time did not show a direct association ($p < 0.05$). Thus, showing that the interaction between gender and sports participation had no significant effect on visual reaction time scores.

Table 1: ***Comparison of mean scores in ms for visual reaction time and visual anticipation time between athletes and non-athletes***

Parameters	Athletes (n=114)		Non-Athletes (n=114)		*t*	p-value	Effect Size
	Mean (in ms)	SD	Mean (in ms)	SD			
RH_SRT	369.31	99.47	468.19	142.63	-6.07	.000	0.80
LH_SRT	356.61	91.35	441.89	131.22	-5.70	.000	0.75
DH_2CRT	419.07	76.55	497.12	108.14	-6.29	.000	0.83
DH_4CRT	529.08	60.93	615.22	79.61	-9.17	.000	1.22
AE5	86.44	40.15	113.86	83.95	-3.15	.002	0.42
AE10	41.64	29.08	75.80	101.36	-3.46	.000	0.45
AE15	73.94	29.07	101.83	48.66	-5.25	.000	0.70
VE5	101.65	86.74	164.96	164.39	-3.64	.000	0.48
VE10	90.61	95.44	129.74	103.93	-2.96	.003	0.39
VE15	166.11	92.25	193.62	81.50	-2.39	.018	0.32

Athletes had statistically significant lower mean errors ($p < 0.05$) for absolute error and variable error across the three speeds tested with a small to moderate effect size (Table 1). As is shown in Table 2, the visual anticipation time (VE15) mean error scores of males were found to be more accurate and consistent compared to females (when compared between athletes and non-athletes), however, the interaction of gender with sports participation failed to reveal any significance for absolute and variable mean errors of the visual anticipation time ($p > 0.05$).

Table 2: ***The significant effect of gender with sports participation on visual reaction time and visual anticipation time***

	Sports Participation	Gender	Sports *Gender Participation	F-value	Partial η^2
RH_SRT	0.000*	0.958	0.972	0.001	0.000
LH_SRT	0.000*	0.441	0.320	0.993	0.040
DH_2CRT	0.000*	0.613	0.835	0.044	0.000
DH_4CRT	0.000*	0.816	0.302	1.072	0.050
AE5	0.030*	0.766	0.070	3.320	0.015
AE10	0.001*	0.077	0.244	1.360	0.006
AE15	0.000*	0.320	0.216	1.540	0.007
VE5	0.000*	0.642	0.999	0.000	0.000
VE10	0.005*	0.165	0.447	0.580	0.030
VE15	0.020*	0.050*	0.434	0.620	0.030

*** significant at $p < 0.05$**

DISCUSSION

This study was designed to assess visual reaction time and visual anticipation time as well as to determine the effect of gender and sports participation on both perceptual skills. Perceptual skills form the foundation of complex cognitive processes as well as the ability to predict and react to a stimulus for an effective response. The visual reaction time defines the interval of time occurring between stimulus presentation and the initiation of a response. This study showed significantly faster mean scores among the athlete population when compared to non-athletes. This could be attributed to the repeated and consistent episodes of sports training and practice that athletes were exposed to. It is speculated that athletes have superior visual skills as compared to non-athletes. According to Gavkare *et al.*[3], a faster reaction time among athletes over non-athletes indicates improvement in their concentration and alertness, better muscular coordination as well as improved performance at speed. Therefore, a faster visual reaction time would benefit athletes by enabling them to react quickly to the demands of their sports.

Other sports vision researchers have also found that athletes have a faster visual reaction time response compared to non-athletes[29]. Akarsu *et al.*[5] demonstrated similar findings. These studies concluded that involvement in sports activities had a positive impact towards an athlete's eye-hand response. It is interesting to note that the statistical findings on the effect of gender on VRT were found to be insignificant. The association of gender with sports participation has very little to almost no influence on visual reaction time scores. This is probably attributed to the higher involvement of females in sports[30].

The results of this study showed that athletes consistently performed with fewer errors as compared to non-athletes, thus supporting the evidence that athletes have better anticipation ability. Both athletes and non-athletes showed a similar pattern of increasing error and reducing consistency as the speed of stimulus increased. The statistical analysis revealed a moderate to high level of effect on all the parameters examined. The reason for this is not clear but may be multifactorial, for example, the amount of training, consistency of training, experience, and level of skill acquisition[15,29]. The effect size seen in this study with regards to the visual reaction time and visual anticipation time warrants further investigation in other age groups.

This study found that the effect of athlete and non-athlete on gender in visual anticipation time was not congruent with other previous studies[15,31,32], where males were found to outperform females. In this study, gender was not found to be a significant factor with regards visual reaction time and visual anticipation time. It is possible that the male involvement preponderance in those sports with anticipatory demands and motor factors were an attributing factor to the higher accuracy and consistency seen[33,34]. Another consideration is that females are more conservative in their approach to motor responses and have lesser spatiotemporal skills[16]. In this study, there was no significant interaction between gender and sports participation, suggesting that gender does not play a major role in sports performance among these 13 to 16 years old school athletes.

The improvement of these two visual perceptual skills could lead to better sports achievement and may be an indicator for talent identification. However, the limitations of the present study lie in the narrow age range and inclusion of a variety of sports, which might have affect obtaining results with more significant effects. Therefore, further cohort studies involving a larger range of age groups with focus to specific sports are recommended to determine the effect of visual reaction time and visual anticipation time over a wider range of sports.

CONCLUSION

The current findings add to the growing body of literature on visual reaction time and visual anticipation time involving an athletic population. Although gender did not significantly affect the visual reaction time and visual anticipation time response, it was shown that greater involvement in sports activities improves an individual's eye-hand reaction time and anticipation time responses. This research demonstrates that visual reaction time and visual anticipation time could play a significant role in the betterment and enhancement of an athlete's sporting abilities. Analysis of both visual reaction time and visual anticipation time measurements should be utilized in designing and executing a visual training program aimed at optimizing athletes' visual skills as a part of the strategy to enhance and optimize their sporting performance. With the growing interest among coaches and sports physiologists on the importance of visual reaction time and visual anticipation time, more future research should be conducted, and the refinement of an athlete's visual function in relation to their sports performance be further explored.

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