

Original Article

## Evaluation of Sustained Attention Performance and Reaction Time in Elite Marksmen

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**Abstract:** The aim of this study was to evaluate Sustained Attention Performance and Reaction Time in Shooters of National Rifle, Pistol and Trap Teams and compare these groups with each other. In this causal-comparative study, 33 players of men national teams, including 11 from rifle team, 11 from pistol team and 11 from trap team were selected by available sampling method and evaluated using continuous computer performance test. Covariance method was used to compare the variables of continuous performance test including (number of errors and reaction time) between the three groups. The results showed no significant difference in the performance of sustained attention and Reaction Time between the three groups ( $P > 0.05$ ), despite the superiority of the trap group in both components. Based on the findings of the present study, the performance of sustained attention and reaction time in the shooters of the national teams of rifle, pistol and trap is equally important. These findings can be justified by the similar nature of different shooting disciplines in the use of sustained attention and reaction time.

**Keywords:** Human Performance; Attention; Shooting;

## 1. Introduction

Attention is one of the most important cognitive aspects known as concentration and alertness and is divided into selective, divided, transitional and sustained types that are controlled by specific brain regions (Davis, 2010). Selective attention is the inhibition of responding to unrelated stimuli (Denckla, 1996); divided attention is the attention to more than one factor at a given time (Eisenhower, 2000), transitional attention is directing attention to a stimulus and inhibiting the allocation of attention resources to unrelated stimuli (Johnson and Proctor, 2004) and sustained attention is the capacity to maintain concentration and alertness over time (Mirsky et al., 1991). In another definition, sustained attention is defined as the readiness to detect changes in the environment and to respond to them occurring at random intervals over long periods of time (Berardi, Parasuraman, and Haxby, 2001) and in addition to being defined as a skill for maintaining focus and performance for a relatively long period of time, it also includes the ability to respond quickly to the target stimulus as well as the inhibition of responding to other stimuli (Mirsky et al., 1991). Sustained attention is controlled by reticular formations, brainstem, and forehead areas (Nejati and Izadi Najafabadi, 2012) and it is the most basic and simplest level of attention that other types of attention need, and therefore, its possible defect can indicate a defect in other types of attention (Sohlberg, and Mateer, 2001).

Cognitive functions can be measured using a variety of domains, such as attention, executive function, memory, language, and emotion (Stroop, 1935). Attention is a cognitive process and is defined as selectively focusing on one aspect of the environment while other aspects are ignored. Attention is also attributed to the allocation of resource processing (Spreen, & Strauss, 1998). Attention is one of the requirements for proper performance in sports, in such a way that in some sports, such as shooting, the lack of attention, even for a moment, leads to a catastrophic change in the outcome of the match.

In many sports, concentration and alertness are very important. In sports fields, athletes must focus on the competition in the presence of interfering and distracting factors, and this cognitive factor is considered as one of the important factors for focus-oriented sports such as shooting. Attention means focusing the awareness on a limited range of stimuli and ignoring other stimuli. In sports, this important task deals with focusing on related features and

maintaining attention (vigilance) and provides the development of appropriate reaction to a certain stimulus (Casting, 1993). Proper reaction requires special levels of attention and speed considering the sports position, and the importance of this issue is more evident in some sports, such as shooting, and in some sports posts, such as goalkeeping. The main goal of coaches and athletes is to achieve better performance during sports competition. Therefore, acquiring sufficient knowledge about the important factors affecting sports performance is essential.

The simple reaction time is determined as a specific response to the stimulus presented at the maximum speed and the person does not need to identify the stimulus and response. Due to the great importance of reaction time in sports and human life, a lot of researches have been done in these field and various factors affecting reaction time (including age, sex, number of stimuli, exercise, stimulus intensity, type of stimulus, arousal, intelligence, brain damage, superiority, focal and peripheral vision (peripheral color), personality type, stimulant drugs, learning disorders, hunger, and heat and humidity of the environment (Delignières, Brisswalter, 1995; Hall-Zazueta, 2011; Jimenez, 1991 and O'Donnell, 2008) can be mentioned. It has also been shown that reaction time can vary in different mental and emotional conditions of individuals (Edwards, 2002). Reaction time is an important factor in many sports and reducing reaction time leads to successful performance. Due to the great importance of reaction time, any factor that shortens the reaction time and in other words increases the reaction speed, is followed by a better performance in the skills that the reaction time is the determining factor (Delignières D, Brisswalter, 1995).

Researches on the importance of attention, time reaction and sport performance indicate that there are different results depending on the type and complexity of the activity. It has been reported that performance in cognitive, neuromotor, and emotional sports require the highest sustained attention and speed of response (lower reaction time), but muscular activities such as strength and endurance are less important for sustained attention and reaction time (Hall-Zazueta, 2011).

Shooting skills depend on a high level of attention. In shooting, successful performance occurs when the athlete, while having a desirable level of mental and physical energy, is able to focus his attention on the



task (Vaez Mousavi, 1995) and continuously maintain his attention. It has been argued that superiority in the performance of motor skills is directly related to the extent to which attention is paid to the appropriate performance factors for a longer period of time (Schmidt, 1991). If sustained attention, such as psychomotor abilities, is inherent and unchangeable (Fleishman & Quaintance, 1984), its high level will be recognized as a component of selection in the national shooting team and reinforces the assumption that having high concentration can be effective in developing shooting skills and ultimately achieving the highest level of sport and championship. On the other hand, if the opposite assumption is confirmed; i.e., concentration is gradually acquired or learned during the shooting practice, then it requires athletes to try to improve their level of attention and pave their ways to success in shooting disciplines.

Researches have also shown that shooters have a significant need for information processing speed and response speed (Elsass P, Zeeberg, 2010). Most of the studies conducted in this field have been done in the field of information processing speed or attention in general, and few studies have specifically addressed the rate of response as well as the dimension of sustained attention. Some researchers have reported that the effect of stimulus presentation speed and stimulus quality on the performance of athletes is obvious. Mani & Bedwell & Miller (2005) have stated that habituation occurs when stimuli are presented more rapidly, which can lead to increased response speed and increased error; therefore, the speed of stimulus presentation may lead to different results in different studies.

Shooting is a competitive sport in which the skills of athletes (such as speed and accuracy) are tested using a variety of weapons, such as firearms and air weapons (World Shooting Federation Munich, 2014). Therefore, speed of response and attention are among the factors that are effective in targeting sports such as shooting. Accuracy and speed in shooting are the important components in determining the fate of competitions. Moreover, despite the general classification known for the needs of the shooting sport, there are differences between the various branches of this sport. For example, shooting competitions with ISSF rifles include shooting competitions towards targets at distances of 10 meters, 50 meters and 300 meters (Ajarlu, 2001). On the other hand, the pistol competitions of the International Shooting Sports Federation (ISSF) include shooting towards targets at a distance of 10 meters, 25 meters

and 50 meters (World Shooting Federation Munich, 2014); finally, in the trap field, 15 devices are installed in the basement, so that the axis of their throwing arm is 50 cm lower than the shooter's foot, in 5 groups of 3, which are located 15 meters away from these devices in the parallel axis of 5 shooting stations (World Shooting Federation Munich, 2014).

There seem to be differences in the amount of sustained attention and response speed required by athletes in different shooting disciplines; therefore, the aim of this study was to compare sustained attention and response speed in rifle, pistol and trap shooters. In other words, the researcher in this study seeks to prove the hypothesis that the rifle, pistol and trap shooting sports, to different degrees, require the ability of sustained attention and speed of response.

## 2. Materials and Methods

The present study is a causal-comparative post-event study. The statistical population studied in this study included players invited to the national teams of rifle, pistol and trap. All participants in this study had at least one year of experience in the national team. Statistical sample was selected using the available method consisting of 11 players of the men's national rifle team, 11 players of the men's national pistol team and 11 players of the men's national trap team, who were parallel in terms of age, intelligence and shooting history. According to the research method, this number was sufficient to obtain a statistical power of 0.85 (Elsass P, Zeeberg, 2010). In this study, three groups of participants were studied and compared. Athletes' cognitive performance level in the field of sustained attention and reaction time was measured using a computer-based continuous performance test. Finally, the cognitive performance of the athletes of the national rifle, pistol and trap teams was measured through descriptive statistics and multivariate analysis of covariance using SPSS software version 16.

### 2-1. Method of Data Collection

*Demographic profile questionnaire:* This researcher-made questionnaire collects demographic information of the subjects such as age, intelligence and history of shooting sport.

*Raven's Progressive Matrices:* The Intelligence Questionnaire used was Raven's Progressive Matrices (Progressive Matrizen). Raven's Progressive Matrices (often referred to simply as Raven's Matrices) or RPM is a non-verbal test typically used to measure general human intelligence and abstract reasoning and is regarded as a non-verbal estimate of fluid intelligence. It is one of the most common tests administered to



both groups and individuals ranging from 5-year-olds to the elderly. The questions asked in these matrices are all the same and they follow the same pattern of pictures and borders that are adjusted in a special way. Subjects must first discover the logic on which the pattern of each question is based, and then choose from the sub-item that completes the pattern of the question. Raven's Matrices are in a way that they are equally new to the subjects. Therefore, having better social and educational conditions do not have much effect on answering the questions.

*Continuous Performance Test (CPT):* The Continuous Performance Test (CPT) is a computer-based test designed to assess sustained attention, response inhibition, response speed, and impulsivity that can be used by people aged 6 to 55 and takes 14 minutes to complete. The test consists of six blocks and each block consists of three sub-blocks (each containing 20 attempts). The distance between the stimuli is variable (including 1, 2 or 4 seconds) and the presentation time of each stimulus is 250 thousandths of a second. The test participant's task is to answer all the letters presented on the screen except the letter X by pressing the space bar. The test consists of two experimental and main stages. The experimental phase is performed for one minute before the main phase to find out if the participant has heard the instructions (Conners, 2002). The test was designed by Rosold et al. in 1956 and quickly gained widespread acceptance. This test was first used to measure brain damage; gradually, its use expanded. In the 1990s, this test was used as the most common laboratory method in assessing children with "hyperactivity with attention deficit disorder." The purpose of the test is to measure the maintenance of attention and arousal in these children (Hadianfard et al., 2000).

So far, various forms of "continuous performance" test have been prepared for therapeutic and research purposes, and in all forms, the subject should draw attention to a relatively simple set of visual or auditory stimuli for a while and press the target stimulus when it appears. In recent researches, visual stimuli are provided for a short time on a computer screen, and the subject must respond to the target stimulus by pressing one of the keys on the keyboard (Alberts and Miri, 1992; Quoted by Hadianfar et al., 2000).

In the present study, the Persian version of the continuous performance test, developed and validated by Nazari, Aghazadeh and Poor Sharifi (2011), was used. This test is performed with the help of a computer. This test has 360 Persian numbers (numbers one to nine) as a stimulus, of which 90% as

a target stimulus and 10% as a non-target. The interval between the presentation of two stimuli is 1, 2, or 4 seconds and the presentation time of each stimulus is 250 thousandths of a second. The test participant's task is to answer all the numbers presented on the screen except the number 5 by pressing the space bar. The reliability coefficients of different test indices were obtained by correlation coefficient method in two runs, which was calculated at a distance of 20 to 30 days on 30 normal participants, in the range between 0.45 to 0.77. Test validity was assessed by criterion validity and concurrent validity. Criterion validity was performed by comparing the normal group with the hyperactive group with attention deficit using t-method, which showed a significant difference between the performances of the two groups (Nazari et al., 2011).

### 3. Results

Considering the effectiveness of sustained attention and speed of response to the variables of age, intelligence and shooting history, the significance between these variables for the groups was examined using analysis of variance.

The average age of the subjects in the three groups of rifle, pistol and trap were respectively, 33.00, 30.25 and 43.72 years; the average intelligence of the subjects of rifle, pistol and trap were respectively, 98.51, 98.45 and 97.86, respectively; the average shooting history of the rifle group was 14.52 years, the pistol group was 12.08 years and the trap group was 14.40 years. The results of analysis of variance showed that there was no significant difference in intelligence variables between the three groups, but there was a significant difference ( $p > 0.05$ ) in the variables of age and shooting history between the three groups. Therefore, in subsequent analyzes, the effect of age and shooting history variables was controlled using analysis of covariance.

Descriptive indicators of the number of errors variables and response speed for each of the groups participating in the study are reported in Table 1.

Table 2 shows the results of analysis of covariance of sustained attention variables. As it can be seen in Table 2, the results of analysis of covariance show that after controlling the effect of age and shooting history, there is no significant difference ( $p > 0.05$ ) between the average number of errors by the three groups studied. However, a small difference can be observed between the average number of errors in the three groups, so that the trap group has the lowest error rate (13.00) and the pistol group has the highest error rate (18.60).



The results of covariance analysis of response speed in Table 3 show that there is no significant difference ( $p > 0.05$ ) between the three groups in terms of response speed. Although the comparison between the

means showed little difference and the difference was that the response rate was lowest in the rifle group (3.50) and highest in the trap group (4.11).

**Table 1.** Descriptive statistics of sustained attention performance and response speed in the three groups studied

Continuous performance variables	Rifle		Pistol		Trap	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Sustained Attention	18.60	8.44	18.12	11.08	13.00	8.52
Response Reaction	3.50	37.54	3.90	74.90	4.11	87.24

**Table 2.** Results of multivariate analysis of covariance for sustained attention in three groups with control over age and shooting history

	Total squares	Degrees of freedom	Mean squares	F-Statistics	Significancy	Effect Size	Power of test
Age	13.702	1	13.702	0.153	0.699	0.02	0.24
Shooting History	34.753	1	34.753	0.389	0.539	0.05	0.50
Group membership	26.689	2	13.345	0.149	0.862	0.06	0.46

**Table 3.** Results of multivariate analysis of covariance for response speed in the three groups studied with control over age and shooting history

	Total squares	Degrees of freedom	Mean squares	F-Statistics	Significancy	Effect Size	Power of test
Age	1390.242	1	1390.242	0.231	0.635	0.04	0.48
Shooting History	1.626	1	1.626	0.001	0.987	0.01	0.16
Group membership	12214.388	2	3107.194	1.015	0.367	0.07	0.69

## Discussion

The aim of this study was to evaluate Sustained Attention Performance and Reaction Time in Shooters of National Rifle, Pistol and Trap Teams. The findings of the present study show that the sustained attention in trap shooters was higher than the other two groups. The group also had a faster response rate than the rifle and pistol groups. Although these differences were not statistically significant, they indicated the relative superiority of trap shooters in the variables of response speed and selective attention to rifle and pistol groups. These results can be explained by examining the difference between trap shooting and rifle and pistol shooting. The uncertainty of the target in trap shooting and the importance of maintaining a state of readiness to shoot with maximum speed and accuracy compared to shooting at fixed and specific targets is a reason for the importance of better

performance in selective attention and response speed of shooters in this field. However, it is not possible to make a big difference between the performance of sustained attention and the speed of response in the shooters of the national teams of rifles, pistols and traps, and it should be noted that the effect of these variables on the successful performance of each shooting branch is equally important.

It is in this regard that recent researches refer to the fact that most of the sensory cues reach the projection regions of the cerebral cortex and are differentiated into conscious perception and irrelevant information by relating to other regions (Indiasi, 1989). However, there was no study that, like the present study, compared the selective attention and response speed of the elite shooters of the national rifle, pistol, and trap teams; however, considering that this study tried to control the effect of other variables affecting selective attention and response speed such as age and





history of shooting and the main difference between these groups was only in some psychological variables, it can be said that selective attention performance and response speed in these groups are comparable and consistent with the results of studies such as Tomperowski, 2003; Vivo et al., 2004; Smith et al., 2010; Etgen et al., 2010 and Vaez Mousavi et al., 2003, which have determined the performance of sustained attention and speed of response in performing sports with cognitive perceptual contexts. Of course, most of the researches done on statistical populations have been different from the present study; e.g., Eskandnejad (2013), which has examined sustained attention in active and inactive elderly people. Selouki et al. (2011) showed a comparison between motor function and sustained attention in children. Alilou (2012) has compared executive functions and sustained attention in students. Azizpour et al. (2014) have compared the sustained attention and reaction speed of patients with multiple sclerosis. In the present study, a review of the literature on research on sports and cognitive functions showed that exercise is associated with improved cognitive processes, cognitive speed, and motor function. Recent studies by Forte et al., (2013) indicate the role of physical activity in improving cognitive function. Active elderly people performed better in all cases. These findings showed that there is a significant and positive relationship between age index with error rate and reaction time in providing correct answers. Exercising regularly can reduce the rate of age-related attention deficit hyperactivity disorder. On the other hand, psychosocial factors such as depression, anxiety and stress are also associated with reaction speed (Bonin et al., 2004).

Shooting is a complex skill that depends on precise muscle control and involves a number of perceptual/cognitive factors. For this reason, the need for sustained attention and high response speed in this sport is quite noticeable. According to the researchers, shooting experiences are considered to be the basic condition for shooters' success (Ajarlu, 2001). Despite the importance of attention in cognitive skills such as shooting, the results show that having a higher level of attention is not necessarily associated with progress in shooting (Vaez Mousavi, 1988). Despite these findings, the researcher has tried to compare two of the most important functional variables in the success of sports athletes with perceptual-cognitive nature. The researcher is to examine the functional differences between different shooters and their importance in different fields of shooting sport and

then determine the position of these components as important components in identifying and cultivating sports talents in each field of shooting. Although various studies have compared the differences of these variables between different sample groups and on the other hand have determined the effectiveness of these components of exercise and physical activity, but so far, the importance of these variables among elite and national athletes has not been addressed. In the pistol field, due to the distance of the weapon from the center of the body, more torque force is generated than the rifle and this causes the weapon to be more affected by the fluctuations of the situation, which is manifested in shooting by increasing the response time. (Pellegrini, 2005 and Lakie, 2010).

As the results of this study showed, there was no significant difference between the variables of selective attention and speed of response between the groups of rifle, pistol and trap. Explaining these findings, it can be said that all branches of the shooting sports need to have a successful performance in selective attention and speed of response, although this performance was higher in trap shooters. The importance of the attention structure in performing all cognitive tasks is obvious for anyone (Mirdoghi, Ghanbari Hashemabadi and Mashhadi, 2012). One of the factor's affecting attentions is the amount of physical activity of people and in fact having an active lifestyle. Many studies show that physical activity affects the nervous system involved in attention. Electrophysiological and neuroimaging studies have shown that physical activity improves cognitive function by increasing neuro-electrical activity, brain volume, and blood flow in brain networks and improves attention levels (Rati, Wolver, 2011).

Therefore, it seems that the players who work at the national team level should have a constant amount of sustained attention and on the other hand, a high response speed compared to other people. Numerous mechanisms have been proposed to describe the relationship between physical activity and cognitive function. These mechanisms fall into two categories: physiological mechanisms and developmental learning mechanisms. Physiological mechanisms include physical changes resulting from physical activity, such as increased cerebral blood flow, changes in neurotransmitters in the brain, structural changes in the central nervous system, and improved levels of arousal. According to learning-developmental mechanisms, physical activity provides the educational experiences necessary for proper cognitive development. Besides, physical



activity stimulates cognitive development (Sibeli and Atner, 2003). Meanwhile, a high level of readiness improves cognitive function (Weuve et al., 2004). There are also evidences about the beneficial effects of activity on various cognitive functions (Kramer and Erickson, 2007). Studies show that physical activity improves executive function, attention, cognitive speed, working memory and implicit memory (Boss, Gill, Santarm and Filho, 2009).

## 5. Conclusion

Despite the obvious importance of sustained attention and speed of response in cognitive sports such as shooting, complete research has not yet been done on the relationship between performance assessment and comparison of these variables in different sports. Overall, given that the present study was a preliminary study to examine the performance of sustained attention and response speed in shooters of the national rifle, pistol and trap teams, the suppositions proposed in line with the results of this study are only hypotheses that necessitate more studies in this field. Due to the limitations of this study in selecting the sample only from athletes of national teams of rifle, pistol and trap and also selecting individuals between 25 and 55 years old (which limit the generalization of the results to athletes outside this age range) and finally due to the limited number of studies that have examined the status of sustained attention and speed of response among athletes, especially shooters, it is suggested to conduct studies that investigate the status of selective attention and speed of response by controlling all influential factors and also deal with researches about women and girls. On the other hand, due to the importance of these variables on the success of shooters, it is recommended to conduct research on ways to improve these variables in the performance of shooters. Instructors and athletes in the field of shooting, especially trap shooting, are also advised to focus their training in order to improve the level of selective attention performance and speed of response. However, it seems that more research in the future focusing on the anatomical-physiological features of the nervous system along with the results of multidimensional psychological tests in different populations of athletes and non-athletes, taking into account the effects of factors such as gender, intelligence, level of daily mental involvement and similar cases can yield more accurate results in this regard.

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## بررسی عملکرد توجه تداومی و سرعت پاسخ‌دهی در تیراندازان خبره

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**چکیده:** هدف از پژوهش حاضر بررسی عملکرد توجه تداومی و سرعت پاسخ‌دهی در تیراندازان تیم‌های ملی تفنگ، تپانچه و تراپ و مقایسه این گروه‌ها با یکدیگر بود. در پژوهش علی-مقایسه‌ای حاضر، ۳۳ نفر از بازیکنان تیم‌های ملی تفنگ (۱۱ نفر)، تپانچه (۱۱ نفر) و تراپ (۱۱ نفر) آقایان به روش نمونه‌گیری در دسترس انتخاب شدند و با استفاده از آزمون رایانه‌ای عملکرد پیوسته مورد ارزیابی قرار گرفتند. جهت مقایسه متغیرهای موردبررسی آزمون عملکرد پیوسته شامل (تعداد خطاها و زمان واکنش) بین سه گروه از روش کوواریانس استفاده شد. نتایج، بیانگر عدم تفاوت معنی‌دار عملکرد توجه تداومی و سرعت پاسخ‌دهی در بین سه گروه مورد مطالعه بود ( $P > 0.05$ ). به گونه‌ای که باوجود برتری گروه تراپ در هر دو مؤلفه اما این یافته معنی‌دار نبود. بر اساس یافته‌های مطالعه حاضر عملکرد توجه تداومی و سرعت پاسخ‌دهی در تیراندازان تیم‌های ملی تفنگ، تپانچه و تراپ به یک‌میزان مورد اهمیت می‌باشد. این یافته‌ها با ماهیت مشابه رشته‌های مختلف تیراندازی در استفاده از توجه تداومی و سرعت پاسخ‌دهی قابل توجیه است.

واژه‌های کلیدی: عملکرد انسان؛ توجه؛ تیراندازی؛

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این نماد به معنای مجوز استفاده از اثر با دو شرط است یکی استناد به نویسنده و دیگری استفاده برای مقاصد غیرتجاری.