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Research Paper: Reaction Time and Anticipatory Skill in Patients Undergoing Percutaneous Coronary Intervention Compared With Normal Controls: A Pilot Study

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ABSTRACT

Introduction: Percutaneous Coronary Intervention (PCI) is a non-surgical procedure for the treatment of Coronary Artery Diseases (CADs). One of the most common disorders associated with these procedures is the occurrence of Cognitive Impairments (CIs). This study aimed to assess the Reaction Time (RT) and anticipatory skill of PCI patients and healthy subjects, using computer-based software as a safe and easy method.

Materials and Methods: Ten male PCI patients and ten healthy male individuals participated in this cross-sectional study. Auditory choice and complex choice RT, visual choice and complex choice RT, and anticipatory skill of the low and high speed of the ball of both groups were analyzed by Speed Anticipation Reaction Test (SART) software.

Results: No significant difference was seen between two groups in terms of simple auditory RT (P=0.15), auditory complex choice of RT (P=0.19), and anticipatory skills of the low speed of the ball (P=0.16). However, the performance of PCI patients was significantly worse on the simple visual RT (P=0.01), visual complex choice RT (P=0.05), and anticipatory skill of the high speed of the ball (P=0.04) compared to those of the healthy controls.

Conclusion: The assessment of RT and anticipatory skill as neurocognitive tests is considered to be one of the useful methods for evaluating the cognition function of patients, who have cardiovascular diseases. Furthermore, the pilot study suggests that PCI patients had a similar or even poorer performance in cognitive function compared with healthy people.

1. Introduction

Coronary Artery Disease (CAD) is one of the most common forms of cardiovascular diseases, which is a leading cause of mortality, disability, low quality of life, and a financial burden [1, 2]. In addition, several studies have reported that Cognitive Impairment (CI) is a prevalent dysfunction in CAD patients [3-5]. Among different treatment strategies, Percutaneous

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Coronary Intervention (PCI), as a revascularization method, may be associated with some degrees of CI [6].

The recent studies revealed that CI in CAD was associated with a low Left Ventricular Ejection Fraction (LVEF), medication, hormones, and biomarkers [7, 8, 11]. Also, according to the recent studies, the results demonstrated that patients with CAD had white matter lesion and smaller brain volume, which was a predictor of cognitive dysfunction [7-14].

It has been established that the Reaction Time (RT) and anticipatory skill act as essential domains of cognitive function among all individuals [15]. RT is defined as the time between the presentations of a sensory stimulus to the onset of response [16]. It is used as an indicator of cognitive function, which is associated with the speed of information processing in the central nerves system [17].

Various factors such as age, gender, type of stimulus, and stimulus intensity affect the RT [18]. On the other hand, anticipatory skill is defined as the ability to anticipate a future event based on information, which causes effective motor performance [19].

Recent studies have focused on the CI of CAD patients, but less is known about these PCI effects on RT and anticipatory skill [20, 21]. In addition, it seems that the measurement of RT and anticipatory skill is a simple and valuable method for assessing the cognitive function in CAD patients.

Therefore, this study aimed to compare visual, auditory RT, and anticipatory skill of patients after PCI compared with healthy controls.

2. Materials and Methods

Ten male CAD patients (Mean±SD age: 54.9±7.6y), who underwent elective or acute PCI during the past 4 weeks, and 10 healthy men (Mean±SD age: 51.5±5.1y), who did not have any cardiovascular risk factors, were selected to participate in this study. Eligible patients were identified through the lists on cath lab of Imam Khomeini Hospital, Tehran city, Iran. Additionally, an interventional cardiologist evaluated the eligible patients based on the inclusion and exclusion criteria.

The inclusion criteria consisted of being 40-60 years old, lacking any visual or hearing impairments, and being right-handed. The participants with a history of chronic neurological or metabolic diseases, color-blindness, and any stimulant drinks (tea, coffee, and alcohol) before the test session and potential inability to continue the test were excluded.

All participants completed the demographic characteristics form and the Persian version of the Mini-Mental State Examination (MMSE) questionnaire. This survey has a sensitivity of (90%) and specificity of (93.5%) to identify any possible CI [22]. Its total score ranges from 0-30 points. Patients who gets a score of 23 or greater were included in the study.

Study procedure

RT and anticipatory skill were evaluated by SART software, which was installed on a laptop connecting to a 24 inch LCD monitor. The reliability and validity of this software had been already assessed [23]. The participants were seated in front of a monitor, and the examiner selected the RT and anticipatory skill tests randomly via the laptop (Figure 1).

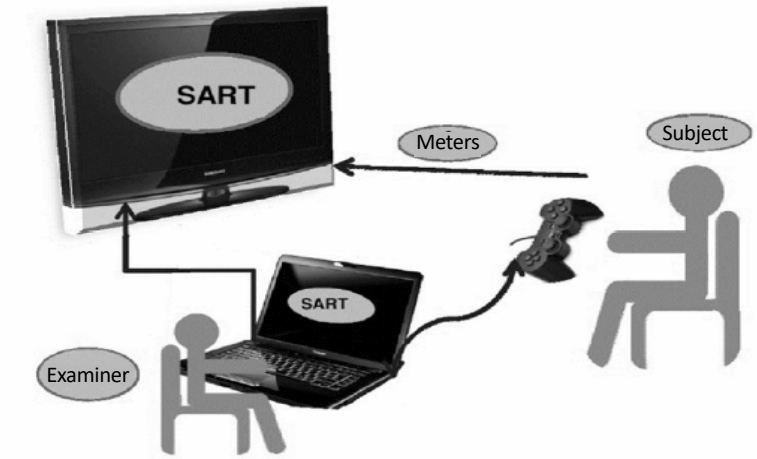

Figure 1. Schematic view of the SART set-up

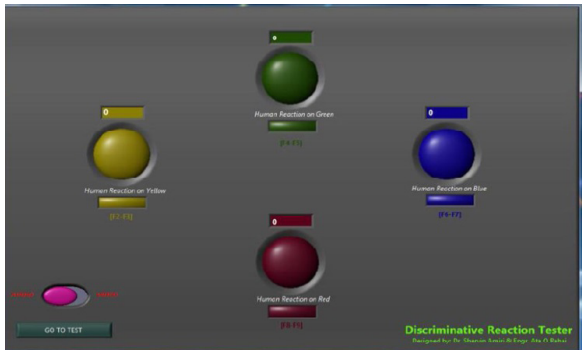

Figure 2. Visual and auditory RT test

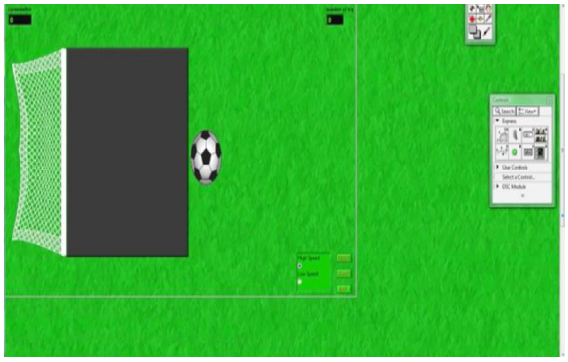

Figure 3. Anticipatory skill estimation test

The SART has 6 cognitive tests of auditory choice and complex choice RT, visual choice and complex choice RT, and anticipatory skill of the low and high speed of the ball. In the beginning, the participants had self-training to become familiar with the software.

In the RT test, the visual stimulation was performed by 4 light bulbs in red, yellow, green, and blue color appearing on the screen (Figure 2). The auditory stimulation was played, using frequencies of 500Hz, 1000Hz, 7000Hz, and 3000Hz. The examiner randomly selected one of the buttons related to the 4 visual lights or sound with different frequencies on the laptop. After appearing the light or hearing the sound, the participant should press one of the keys matching the light or the sound immediately.

The visual and auditory complex choice RT was measured by selecting the reverse key option in the software. Therefore, after examiner activated this option on the test screen, the subject had to press the button in the opposite direction. Each test was performed in five sets of ten repetitions (50 times). If the subject made more than five errors in 50 trials of RT tests, the examiner would repeat the test.

In the next step, the examiner started the anticipatory skill test, which showed a soccer ball moving horizontally from right to left side of the screen with a constant speed and disappearing before reaching the gate.

When the chronometer of the system started, the participant had to estimate the expected time for the ball to reach the gate and press the corresponding button (Figure 3). The anticipation test was assessed with high and low speed. The test was performed in three sets of ten repetitions (30 times). Finally, the SART software calculated the average time taken by the participant in each test and reported the time in milliseconds. The examiner took the test from all subjects in the same quiet room and the middle of the day.

Statistical analysis

All analyses were conducted in the SPSS V. 19. The Kolmogorov-Smirnov test was used to evaluate the normal distribution of all parameters. As a result, all data were normally distributed ($P<0.05$). Also, descriptive statistics, t-test, and Pearson's correlation coefficient were performed. The data analysis was performed at a significant level of 0.05.

3. Results

In this study, the information of two groups of 20 participants (10 PCI patients and 10 normal control) was analyzed. (Table 1) presents the mean and standard deviation of the demographic characteristics of the participants. According to the results, there were no significant differences between the two groups in their mean age, weight, height, BMI, and educational level.

Statistical analysis showed significant differences between the PCI and control groups in three neurocognitive tests. PCI patients had significantly longer simple visual RT ($P=0.01$), visual complex choice of RT ($P=0.05$), and anticipatory skill of the high speed of the ball ($P=0.04$) compared to the healthy controls (Table 2).

No significant differences between two groups were seen in simple auditory RT ($P=0.15$), auditory complex choice of RT ($P=0.19$), and anticipatory skills of the low speed of the ball ($P=0.16$). (Table 2) presents the t-test results of all neurocognitive tests in both groups.

On the other hand, the analysis revealed that the PCI patients were significantly worse in the performance on the visual RT and anticipatory skill of the high speed of the ball compared to the normal controls.We assessed the relationship between the level of education and RT and anticipatory skill (Figures 4 and 5). There was a significant positive correlation between the educational level and simple

Table 1. Mean±SD of demographic data of the PCI group (n=10) and normal group (n=10)

Variables	Mean±SD		P
	PCI	Normal	
Age (y)	54.9±7.6	51.5±5.1	0.26
Weight (kg)	89.6±16.5	84.1±9.8	0.38
Height (cm)	176±5.8	175±8.13	0.75
BMI (kg/m^2)	28.97±5.49	27.58±3.83	0.52

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Table 2. Comparison of the means of neurocognitive tests in the PCI group (n=10) and normal group (n=10)

Variables (ms)	Mean±SD		P	Effect Size*
	PCI	Normal		
Visual choice RT	618.23±201.23	423.26±78.1	0.01	0.71
Visual complex choice RT	781.32±228.34	617.65±140.78	0.07	0.77
Auditory choice RT	1223.65±506.59	969.05±188.85	0.15	0.6
Auditory complex choice RT	1525.4±588.81	1231.32±342.8	0.19	0.68
Anticipatory skill with high speed	490.08±197.17	344.75±89.57	0.04	0.59
Anticipatory skill with low speed	1322.89±802.38	872.26±546.98	0.16	0.48

*All variables entered in the model: BMI, Education, Group, and Education group

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visual and auditory reaction (r=0.78, P<0.001) and visual and auditory complex choice of RT (r=0.7, P=0.001). In addition, there was a significant positive association between the level of education and anticipatory skills of the high and low speed of the ball (r=0.45, P=0.04). Nevertheless, it seems that higher education can be related to better cognitive function and faster RT.

In this study, there was no statistically significant correlation between BMI and RT, as well as anticipatory skill. In addition, there was a negative correlation between BMI and the auditory choice RT, but it was not significant (Table 3).

4. Discussion

This study was designed to investigate the RT and anticipatory skill of PCI patients compared to the control group, using the SART software.

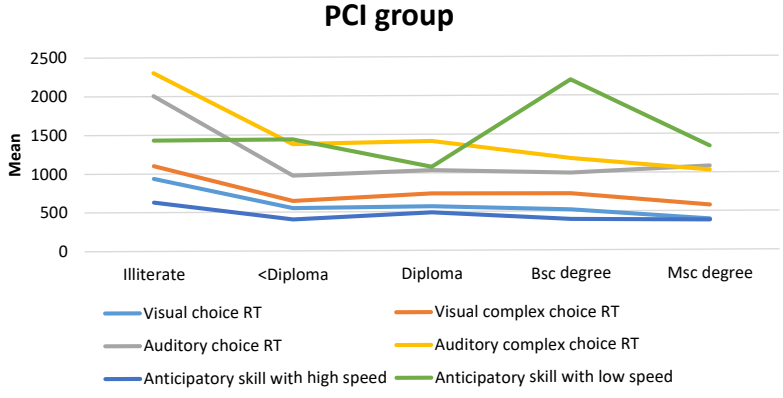

Figure 4. The Pearson correlation coefficients between education level with RT and anticipatory skill

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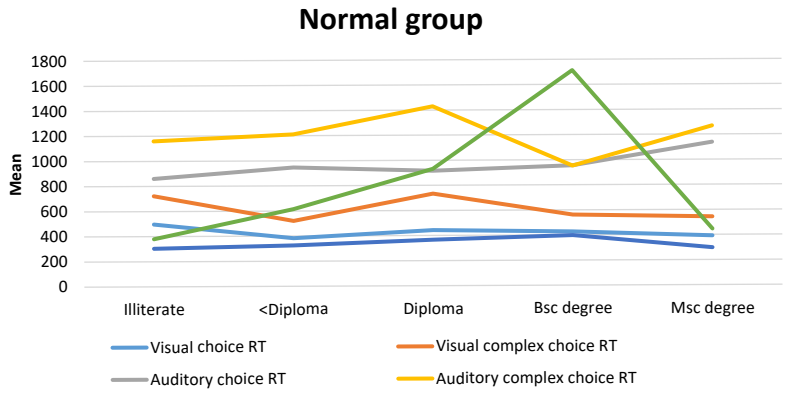

Figure 5. The Pearson correlation coefficients between education level with RT and anticipatory skill

The results indicated that PCI patients had a slower visual choice and complex choice RT compared to the healthy controls. The auditory choice and complex choice RT of the PCI group was slower than the control group, although these differences were not statistically significant.

Furthermore, to distinguish among the four different sound frequencies, the participants need to spend more time to become familiar with the sounds. In addition, they require to use their working memory to memorize and identify different sounds during the test period [24]. It appears that the PCI procedure might not affect the performance of memory function and the auditory RT [25].

Moreover, the results of anticipatory skill test indicate that the PCI patients had a poor performance to anticipate the ball of high speed compared with the normal group. But, the task of the low-speed ball did not show the same results.

Patients with cardiovascular risk factors are known to have an increased risk of white matter lesion progression, which is associated with CI, especially in executive function and information processing speed domains [26-28].

However, several studies have evaluated the cognitive function of the patients, who underwent cardiac surgery and coronary artery bypass grafting [29-34]; but, a few observational prospective studies have demonstrated the effect of PCI procedures on cognitive function in CAD patients [3, 35].

The results reported by Devapalasundarum et al. indicate that CAD patients initially have a poor baseline cognitive performance [3]. Also, these results imply that some of the patients show a new CI after Coronary Angiography (CA). The researchers used various computerized test series to assess psychomotor function (simple RT), attention (choice RT), memory, and executive function after CA and concluded that some patients had cognitive dysfunction. Their results were confirmed by other studies, which described a cognitive dysfunction following PCI [36, 37].

Jurga et al. conducted a study to measure cognitive function in patients after CA and PCI, using the Montreal Cognitive Assessment (MoCA) test [25]. They concluded that no cognitive dysfunction was found after CA or PCI intervention. Based on a study carried out by Selnes et al. the CI is transient or reversible [38].

Table 3. The Pearson correlation coefficients between BMI with RT and anticipatory skill

Variables	R	P
Visual choice RT	0.08	0.72
Visual complex choice RT	0.16	0.48
Auditory choice RT	-0.7	0.77
Auditory complex choice RT	0.16	0.48
Anticipatory skill with high speed	0.39	0.09
Anticipatory skill with low speed	0.07	0.77

It seems that the above studies had used very different neuropsychological test series and various methods for measuring the cognitive abilities in PCI patients [20]. Therefore, it is difficult to compare their results about CI after PCI.

Based on the results of the previous studies, it seems that psychomotor function and attention most commonly affected domains in PCI patients, whereas the data are usually scarce about the RT and anticipatory skill after PCI [3, 35, 36].

Other studies on the RT field have been conducted on different groups of athletes by SART software [23, 39]. The results indicated that athletes have better RT compared to the controls [23, 40]. Apparently, the discrepancy in the results can be attributed to the differences within the studied populations such as age, sex, and physical fitness of the participants.

The results of the current study confirm that the poor visual and auditory performances could be negatively affected by increasing age of the patients. It seems that older participants would take a longer time to receive the stimulus and produce a motor response [41, 42].

The results also reveal that a higher educational level can be related to better visual and auditory RT and anticipatory skill in the two groups. In addition, recent studies suggest that the education may contribute higher synaptic density and flexible neuronal pathway [43]; therefore, it can be concluded that the cognitive function and lower incidence of dementia after stroke can be associated with educational levels [44, 45].

According to the results, no significant correlation was found among BMI and RT and the anticipatory skill in both groups. In contrast, some studies indicate that there is a link between obesity and cognitive dysfunction in healthy individuals and patients with heart failure [46].

The present study had some limitations. Firstly, the small sample size may limit the statistical power of the study. Secondly, RT will be affected by several variables, such as fatigue, psychological factors, personality type, etc.

Future studies are needed to find the effects of other coronary artery disease treatments such as drug therapy or coronary artery bypass grafting on RT and anticipatory skill compared to the PCI patients or healthy individuals as a control group.

5. Conclusion

This study is one of the first studies that measures RT and anticipates it in patients undergoing PCI. The results showed that PCI patients had a slower visual RT and lower performance in the anticipatory skill of the high speed of the ball compared with the healthy group. Also, there is a correlation between educational level and these neurocognitive skills in both groups.

Ethical Considerations

Compliance with ethical guidelines

This cross-sectional study had been approved under the (Code: IR.TUMS.FNM.REC.1397.005) by the Ethics Committee of Tehran University of Medical Sciences and all participants signed the consent form.

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This research was a part of the MSc thesis of the first author in physical therapy, Department of Physiotherapy, School of Rehabilitation, Tehran University of Medical Sciences.

Authors contributions

Conceptualization, methodology, writing- review & editing: Narges Dabbaghipour, Mohammad Sadeghian, Azadeh Shadmehr, Behrouz Attarbashi Moghadam; Investigation: Narges Dabbaghipour, Azadeh Shadmehr, Behrouz Attarbashi Moghadam; Writing-original draft: Narges Dabbaghipour, Behrouz Attarbashi Moghadam; Supervision: Mohammad Sadeghian, Azadeh Shadmehr, Behrouz Attarbashi Moghadam.

Conflict of interest

The authors declared no conflict of interests.

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