Ovidius University Annals, Series Physical Education and Sport / SCIENCE, MOVEMENT AND HEALTH
Vol. XXIII, ISSUE 2, 2023, Romania
The journal is indexed in: ERIH PLUS, Ebsco, SPORTDiscus, INDEX COPERNICUS JOURNAL MASTER LIST, DOAJ DIRECTORY OF OPEN ACCES JOURNALS, Caby, Gale Cengage Learning, Cabell's Directories

Science, Movement and Health, Vol. XXIII, ISSUE 2, 2023
June 2023, 23 (2): 208 - 212
Original article

IMPROVING REACTION TIME AND HAND-EYE COORDINATION IN HIGH SCHOOL STUDENTS USING VIRTUAL REALITY: A PILOT STUDY

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Abstract

Aim. Our aim was to investigate whether immersive VR training has the potential to improve hand–eye coordination and reaction time in high school students.

Methods. A total of 16 Romanian students, aged 17-19, were recruited from a high school in Cluj-Napoca. Subjects from the experimental group participated in the intervention program based on virtual reality, subjects from the control group did not participate in any specific training program. The intervention program had a duration of 12 weeks, biweekly, with 40 minutes each session. The subjects were tested before and after the application of the intervention program. Descriptive statistics and t-test were conducted for comparison of subject characteristics between both groups.

Results. A paired samples t-test was performed to compare results in experimental group pre-test and post-test of Alternate-Hand Wall-Toss Test (AHWT) and Deary-Liewald Test.There was a significant difference ($p <.05$) in AHWT Test between pre-test ($M = 24.75$, $SD = 3.012$) and post-test ($M = 28.13$, $SD = 2.696$); $t = -5.974$, $p = <.001$. An independent sample t-test was performed to compare post-test results of AHWT Test and Deary-Liewald Test between experimental group and control group. There was a significant difference ($p <.05$) in post-test results of AHWT Test between experimental group ($M = 28.13$, $SD = 2.696$) and control group ($M = 24.88$, $SD = 2.900$); $t= 2.322$, $p = .018$.

Conclusions. We can conclude that the virtual reality training can be very good for reducing choice reaction time and for improving hand-eye coordination in high school students.

Keywords: virtual reality, reaction time, hand-eye coordination, high school

Introduction

We chose to study the possibility of improvement in reaction time and hand-eye coordination because whether it's an experienced athlete or someone who sits at a desk all day, reaction time plays an important role every day and hand-eye coordination is also an essential skill that children will use daily throughout their adult lives (Mayer & Caminiti, 2018; Rutkowski, Adamczyk, Pastuła, & Gos, 2021). A good reaction time associated with a good hand-eye coordination contributes to the increase of quality of life in humans.

Reaction time has a been a favorite subject of experimental psychologists since the middle of the nineteenth century (Deary, Liewald, & Nissan, 2011).

Reaction time is the time elapsed from the presentation of a sensory stimulus to the onset of the response. Reaction time can be divided into three components:

1. Perception time: the time required to apply and perceive the stimulus;
2. Decision time: the time to decide an appropriate response to the stimulus;
3. Motor time: the time to execute the motor command received in response to the stimulus (Akhani, Gosai, Mendpara, & Harsoda, 2015).

Reaction time is incredibly important to everyday life. It keeps us safe and makes sure our body is ready to move whenever it needs to. For example, when a car suddenly pulls out in front of us, quick reaction time can make the difference between being safe and getting into an accident (Diamond, 2012). The good news is that it is entirely possible to improve reaction times. Strengthening that connection between the body and the brain can make a noticeable difference in our ability to react to the world around us.

Hand-eye coordination can be defined as the ability to perform activities that require the simultaneous use of eyes and hands (Mayer & Caminiti, 2018). This is a complex cognitive skill, because it requires the hands to be guided according to the stimuli that the eyes receive (Rutkowski, Adamczyk, Pastuła, & Gos, 2021).

Interactions with objects and people play a crucial role in understanding how the brain creates internal models of the environment and generates movement in space (Mayer & Caminiti, 2018).

Training for better hand-eye coordination is essential in the modern age. From driving a car to typing we need dexterity. With the increasingly intense technological development, new opportunities have emerged for improving reaction time and eye-hand coordination. A good example of devices used for this matter are HMD devices (Jensen & Konradsen, 2018).

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Currently, virtual reality connected to exercises (exergames) has been gaining prominence in the scientific community. (Barbosa, Frankly, & Sales, 2020; Page, Barrington, Edwards, & Barnett, 2017; Vaghetti, Monteiro-Junior, Finco, & Reategui, 2018; Vaughan, Dubey, Wainwright, & Middleton, 2016).

Exergame is defined as a video game that requires physical activity in order to play (Benzing & Schmidt, 2018; Neumann, Thomas, Moffitt, & Loveday, 2018). The newest types of video games are these who use Virtual Reality (VR), which is a computer-based technology that incorporates input and output devices and that allows participants to experience and interact with an artificial environment as if it were the real world. Virtual Environments (VE) come in many forms and often these are determined by the capabilities of the platform or hardware with which one can experience the VE. What constitutes the key point of VR is immersion and constitutes the perception the user has about his or her existence in a VE (Howard, Gutworth, & Jacobs, 2021). Full Immersion within a VE comes by means of a Head Mounted Display (HMD) and can even include haptic interface devices (hand controllers and joysticks) that enable the users to concentrate and interact on the game by eliminating any external distractions (Jensen & Konradsen, 2018). The HMD is a wearable device that covers the eyes and thus removes vision of the outside world. It has two small screens on which the virtual world is viewed in stereovision with a wide field of view, also is combined with head tracking to allow the user to view areas of the VE that are outside of the immediate field of view by turning their head (Amprasi, Vernadakis, Zetou, & Antoniou, 2021). Recently, virtual reality programs are more and more common in the education field. Whether it is general education or physical education, these programs have been shown to be beneficial in improving cognitive or motor skills (Barbosa, Frankly, & Sales, 2020) (Benzing & Schmidt, 2018) (Vaghetti, Monteiro-Junior, Finco, & Reategui, 2018).

Objectives

This intervention involves motor and cognitive double - task performance, demanding mainly, motor coordination, attention, focus, processing velocity, memory and decision making to interact with virtual environment.

Our aim was to investigate whether immersive VR training has the potential to improve hand–eye coordination and reaction time in high-school students.

Our hypothesis is that through a 12-week exercise program using the Oculus Quest 2 device, students will reduce their choice reaction time and will improve hand-eye coordination.

Methods

Subjects

A total of 16 Romanian students, aged 17-19, were recruited from a high school in Cluj-Napoca. The participants were informed about the risks of participating in the research, we also received the written consent of the students, respectively of the parents for minor students.

Inclusion-exclusion criteria

• Students aged 17 - 19 years
• Clinically healthy
• Not to be engaged in any sports or other form of organized physical exercise

Design

To determine the effect of the intervention program, the participants were divided into two groups, one experimental (n=8) and the other control (n=8). Subjects from the experimental group participated in the intervention program based on virtual reality, subjects from the control group did not participate in any specific training program.

The intervention program had a duration of 12 weeks, biweekly, with 40 minutes each session. In the ***intervention program*** we used HMDs Oculus Quest 2 created by Meta (Facebook Technologies, LLC. 1 Hacker Way, Menlo Park, CA 94025, USA). The means used were exergames Reakt, Thrill of Fight, OHShape and Eleven Table Tennis. The subjects were tested before and after the application of the intervention program.

For the evaluation of choice reaction time we used Deary-Liewald Reaction Time Test (Deary, Liewald, & Nissan, 2011) and for the evaluation of hand-eye coordination we used Alternate-Hand Wall-Toss Test (Mackenzie, 2009).

For training program we used Oculus Quest 2 (Facebook Technologies, LLC. 1 Hacker Way, Menlo Park, CA 94025, USA) as virtual reality tool.

Statistical analysis

Descriptive statistics and t-test were conducted for comparison of subject characteristics between both groups. Independent T test was conducted to compare mean values of the measured variables between both groups; and paired test was conducted to compare between pre and post treatment mean values of the measured variables in each group. The level of significance for all statistical tests was set at $p < 0.05$. All statistical tests were performed through the statistical package for social sciences (SPSS) version 29 for windows (IBM SPSS, Chicago, IL,USA).

Results

A paired samples t-test was performed to compare results in experimental group pre-test and post-test of Alternate-Hand Wall-Toss Test (AHWT) and Deary-Liewald Test.

There was a significant difference ($p < .05$) in AHWT Test between pre-test ($M = 24.75$, $SD = 3.012$) and post-test ($M = 28.13$, $SD = 2.696$); $t = -5.974$, $p = <.001$. There was a significant difference ($p < .05$) in Deary-Liewald Test between pre-test ($M = 412.38$, $SD = 35.238$) and post-test ($M = 381.00$, $SD = 34.822$); $t = 7.961$, $p = <.001$ (Table 1).

Table 1. Comparison between pre- and post-test in experimental group.

		N	Mean	Std. Deviation	Mean Difference	t	df	p
Experimental group	AHWT test Pre-test	8	24,75	3,012	-3,375	-5,974	7	<,001
	AHWT test Post-test	8	28,13	2,696				
Experimental group	Deary-Liewald test Pre-test	8	412,38	35,238	31,375	7,961	7	<,001
	Deary-Liewald test Post-test	8	381,00	34,822				

N, number of subject; t, t-value; df, degrees of freedom; p, p-value

A paired samples t-test was performed to compare results in control group pre-test and post-test of AHWT Test and Deary-Liewald Test.

There was not a significant difference (p >.05) in AHWT Test between pre-test (M = 24.25, SD = 2.605) and post-test (M = 24.88, SD = 2.900); t = -1.667, p = .070. There was not a significant difference (p >.05) in Deary-Liewald Test between pre-test (M = 416.50, SD = 37.394) and post-test (M = 412.38, SD = 33.419); t = 1.729, p = .064 (Table 2).

Table 2. Comparison between pre- and post-test in control group.

		N	Mean	Std. Deviation	Mean Difference	t	df	p
Control group	AHWT test Pre-test	8	24,25	2,605	-,625	-1,667	7	,070
	AHWT test Post-test	8	24,88	2,900				
Control group	Deary-Liewald test Pre-test	8	416,50	37,394	4,125	1,729	7	,064
	Deary-Liewald test Post-test	8	412,38	33,419				

N, number of subject; t, t-value; df, degrees of freedom; p, p-value

An independent sample t-test was performed to compare pre-test results of AHWT Test and Deary-Liewald Test between experimental group and control group.

There was not a significant difference (p >.05) in pre-test results of AHWT Test between experimental group (M = 24.75, SD = 3.012) and control group (M = 24.25, SD = 2.605); t= .355, p = .364. There was not a signifiant difference (p >.05) in pre-test results of Deary-Liewald Test between experimental group (M = 412.38, SD = 35.238) and control group (M = 416.50, SD = 37.394); t= -.227, p = .412 (Table 3).

Table 3. Comparison of pre-test between experimental and control group.

	Group	N	Mean	Std. Deviation	Mean Difference	t	df	p
AHWT test Pre-test	Experimental	8	24,75	3,012	,500	,355	14	,364
	Control	8	24,25	2,605				
Deary-Liewald test Pre-test	Experimental	8	412,38	35,238	-4,125	-,227	14	,412
	Control	8	416,50	37,394				

N, number of subject; t, t-value; df, degrees of freedom; p, p-value

An independent sample t-test was performed to compare post-test results of AHWT Test and Deary-Liewald Test between experimental group and control group.

There was a significant difference (p <.05) in post-test results of AHWT Test between experimental group (M = 28.13, SD = 2.696) and control group (M = 24.88, SD = 2.900); t= 2.322, p = .018. There was a signifiant difference (p <.05) in post-test results of Deary-Liewald Test between experimental group (M = 381.00, SD = 34.822) and control group (M = 412.38, SD = 33.419); t= -1.839, p = .044 (Table 4).

Table 4. Comparison of post-test between experimental and control group.

	Group	N	Mean	Std. Deviation	Mean Difference	t	df	p
AHWT test Post-test	Experimental	8	28,13	2,696	3,250	2,322	14	,018
	Control	8	24,88	2,900				
Deary-Liewald test Post-test	Experimental	8	381,00	34,822	-31,375	-1,839	14	,044
	Control	8	412,38	33,419				

N, number of subject; t, t-value; df, degrees of freedom; p, p-value

Discussions

This pilot study is part of author's doctoral thesis and was conducted to determine the effect of virtual reality on reducing choice reaction time and improving hand-eye coordination in high school students.

Sixteen children who met inclusion-exclusion criteria were selected from a high school in Cluj-Napoca. Their ages ranged from 17 to 19 years old. They were randomly selected into two groups. Both were equal in number. Group 1 (Experimental group) including 4 males and 4 females managed virtual reality program. Group 2 (Control group) including 4 males and 4 females did not participate in any specific training program.

The result of the current study revealed that there were statistically significant ($p <.05$) reductions in choice reaction time, and improvement in hand-eye coordination between pre- and post-test in experimental group. Also, there was a significant difference ($p <.05$) in post-test results of AHWT and Deary-Liewald Test between experimental and control group. The study is in consistend with other studies which affirm the benefits of using virtual reality in reducing reaction time and improving hand-eye coordination.

Amprasi et al. (2021) found in his study methods to improve reaction times with a fully immersive virtual environment (FIVE). Forty eight female players of a volleyball club, 8 to 10 years old participated in 12 practice sessions that were conducted during 6 weeks, twice a week for 24 min each time. Participants of the FIVE group have attended a FIVE program in Playstation4 VR. The study revealed reduction in reaction time in both traditional training (TT) and fully immersive virtual environment (FIVE), compared to a control group that received no training. In Barbosa et al. (2020) study activities increased heart rate in relation to rest, which could be used to break sedentarism, also intervention reduced SRT (simple reaction time). Notably, studies like Petri et al. (2019) using real international successful karate kumite athletes, all of them with the black belt degree (1st - 4th Dan) to build an avatar which was used in the intervention program. Subtracting reaction times from the first reaction of the responding athlete is an appropriate method to analyze changes in perception and anticipation due to training in VR. These new findings can be used in karate training to improve motor learning in beginners to enhance performance (Petri, Bandow, & Masik, 2019). VR training programme of Rutkowski et al. (2021) improved the hand–eye coordination and reaction time of musicians, which may lead to the faster mastering of a musical instruments. Gray (2017) demonstrated that training in VR can be good not only for the musicians but for athletes also: "Training in a VE can be used to improve real, on-field performance especially when designers take advantage of simulation to provide training methods (e.g., adaptive training) that do not simply recreate the real training situation" (Gray, 2017). Gray used in his study 80 males baseball players and distributed them in four group: VE (virtual environment), VE+extra sessions, extra sessions RBT (real baseball training) and normal training group. Duration of the study was 6 weeks, 2 ses/week, 45 minutes each. Players in the VE group showed significant improvements for 7/8 of the batting performance. Another virtual reality based study, single group designed with a duration of 4 weeks, 3 days/week, 20 minutes per session found post-intervention reduction in auditory and visual reaction time (Tharani, Kothari, Shah, & Shah, 2020).

Conclusions

We can conclude that the virtual reality training can be very good for reducing choice reaction time and for improving hand-eye coordination in high school students. With a large variety of devices, some of them at an accesible price more people can try this kind of physical activity for mentaining health, breaking sedentarism or as we shown in our study for reducing reaction time and to improve hand-eye coordination. Advanced technology in designing virtual reality devices is continuously developing and refining to provide accommodation according to consumer demand for better training experiences.The researchers must focus their work on large numbers of populations for a better understanding of the effects of virtual reality programs on reaction time, hand-eye coordination and other psychomotor skills.

Ethics statement

The studies involving human participants were reviewed and approved by The Scientific Council of the Babeș-Bolyai University of Cluj Napoca. The participants provided their written informed consent to participate in this study. This study adhered to the principles of the Declaration of Helsinki.

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