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Effect of a Full Immersive Virtual Reality Intervention on Whole Body Reaction Time in Children

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Abstract: The aim of this study was to investigate the effect of two educational interventions, a program based on Full Immersive Virtual Environment (FIVE) games and a Typical Training (TT) program, in Whole Body Reaction Time (WBRT) of children aged 8-10 years old. Forty-eight female volleyball players of a volleyball club from the city of Komotini, in Greece, participated in this study. They were randomly divided into three individual groups of 16 children each, one Control Group (CG) and two experimental groups (FIVE and TT). The CG did not receive any structured WBRT training program, while the two experimental groups attended a program focused on improving WBRT for 6 weeks, twice a week for 24 min each time. The participants of FIVE group attended a full immersive virtual reality program in Playstation4 VR and the participants of TT group attended a typical training to the court. Before, after and one –month after the interventions WBRT was estimated using the Whole Body Reaction Timer (Takei Instruments), recording the reaction time of 16 attempts (four in each direction). Two-way analyses of variance with repeated measures were conducted to determine the effect of training program groups and measurements across time. Analysis of the data illustrated that the post-test WBRT scores and the one –month retention test SA scores were remarkably greater than pre-test WBRT scores for both experimental groups and not for the CG. In conclusion, FIVE is an effective tool for improving WBRT such as typical training. This research, therefore, will help physical education professionals and coaches to indicate different methods to train WBRT in children.

Keywords: Virtual Reality, Full Immersive, Physical Activities, Whole Body Reaction Time, Children

1. Introduction

It is a fact that, in every skill, there are hidden many abilities (Adam & Willberg, 1986) which constitute the "equipment" with which an individual can perform the skill (Schmidt, 1991). In particular, abilities are distinguished in cognitive, perceptual and motor. More specifically, Perception Abilities (PA) are related to problem –solving processes and the speed of information processing (Magill, 1998). Successful performance in sport requires except of efficient execution of motor behavior, also a high level of PA (Kulpa, Bideau, & Brault, 2013; Mori, Ohtani, & Imanaka, 2002). WBRT belongs to PA and refers to the quick and correct reaction of the whole body in the appearance of a stimulus (Rose, 1998) and dominates during the execution of many open skills or sports. Volleyball is a sport with "opened" characteristics, that is to say, little predictable. As a consequence, the motor performance is directly related to the capacities of foreseeing and answering the alterations that happened in the environment. Specifically, the special features required for high performance in volleyball (speed and accuracy of response successfully), as the main sources that generate information are the ball, the athlete, teammates and adversaries (Dina, Dina, & Popescu, 2013), impose the acquisition of PA, and especial WBRT, as taking part in a sport, involves whole body actions that present postural and inertial challenges (Du & Clark, 2018). Considering all the above, WBRT has been found to be very important in volleyball.

What is significant is that WBRT is a PA that can be developed/ improved through exercise (Olivier, Paul, Walter, Hayes, Foreman, Duff, Schaefer, & Dibble, 2021). Except of typical training programs, exergames can, also, improve attention skills (Satyen & Ohtsuka, 2001; Green & Bavelier, 2003) such as WBRT suggesting an alternative way of developing them. According to Oh and Yang (2010), exergame is defined as a

video game that requires physical activity in order to play. These types of games inspire and motivate the users to exercising by taking advantage of different technologies (Feltz, Irwin, & Kerr, 2012; Nurkkala, Kalermo, & Jarvilehto, 2014). The newest types of high-tech 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. 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. 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 (Alhadad & Aboo, 2018).

Surveys to exergames revealed that, participating in exergames may encourage physical activity (Sinclair, Hingston, & Masek, 2007; Oh & Yang, 2010), improve the teaching of sports-related motor skills (Patel, Bailenson, Hack –Jung, Diankov, & Bajcsy, 2006; Eaves, Breslin, Van Schalk, Robinson, & Spears, 2011) and finally decrease reaction time (Bisson, Contant, Sveistrup, & Lajoie, 2007; Politopoulos, 2015) by making the participation more enjoyable (Faric, Potts, Hon, Smith, Newby, Steptoe, & Fisher, 2019) and appealing to children (Nurkkala et al., 2014). Additionally, according to Pourazar, Mirakhori, Hemayattalab and Bagherzadeh (2018) a four –week training program with VR affects the improvement of reaction time in children with cerebral palsy. Moreover, VR use has significantly increased during the lockdown period due to Covid -19, and users expressed overwhelmingly positive opinions on the impact of VR activities on their mental and physical wellbeing (Siani & Marley, 2021) appearing effective programs for reducing pain intensity and pain-related interference in activity, mood, and stress posttreatment (Garcia, Birckhead, Krishnamurthy, Sackman,, Mackey, Louis, Salmasi, Maddox, & Darnall, 2021).

The review of the literature indicates that the few interventions with VR training programs that have been made until today: a) have not done on developing and improving WBRT, b) were mainly targeted at children or adolescents with clinical conditions and not at volleyball female players, and c) were not conducted in children aged 8-10 years old with a CG. As a result, the paucity of research on the utilization of FIVE training programs in WBRT development, led the authors of this paper to design and carry out a study that addressed the impact of full immersive virtual reality on children's WBRT development, as compared to typical approaches for the development of that PA. Thus this survey is original and is going to fill this gap in the research literature. Exploring whether FIVE to be used in the training of female volleyball players aged 8-10 years old improve their WBRT by examining the short and long term effects.

The purpose of this study was to define the effect of two educational interventions in WBRT of children aged 8-10 years old. A program based on FIVE games and a TT program. More specifically, the study examined the following research questions:

(1) Are there differences in initial mean WBRT test scores between the TT, the FIVE and the CG?

(2) Do children, on average, report differently on the WBRT test for the pre-test, post-test and one –month retention test measurements?

(3) Do the differences in means for the WBRT test between the TT, the FIVE and the CG vary between the pre-test, post-test and one –month retention test measurements?

This study can proposal a useful guidance to the international research community regarding the effectiveness or no of FIVE games as vehicles for improving WBRT among volleyball girls aged 8-10 years –old.

2. Method

2.1 Participants

Forty eight (n=48) female players of a volleyball club, 8 to 10 years –old (mean 9.27±0.77 years) where the children whose parents had expressed interest in participating in the study. Each participant voluntarily provided written informed consent before participation. After the pre -test they were randomly divided into three individual groups of 16 children each. One CG and two experimental groups, the FIVE group and the TT group.

2.2 Procedure

Participants of the CG did not receive any structured training program. Participants of two experimental groups 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 based to improve

WBRT. Whereas participants of the TT group have attended a TT WBRT training to the court. Before, after and one –month after the intervention without practice, assessed WBRT.

2.3 Intervention Program

The participants of FIVE group, prior to the training program with PlayStation4 VR, received an introductory tutorial on how to use the PlayStation4 VR and how to play the specific games. The VR game has been chosen from the "Carnival Games" which would train WBRT was "Climbing Wall". In every session, the participants were able to play this game that was based on training WBRT.

At the same time, the participants of TT group have attended a typical training to the court aiming to develop WBRT. A typical training was, initially warm –up (4 min.), two exercises that were based on training WBRT (24 min.) and stretching (4 min.).

2.4 Measures

To evaluate children's WBRT, the Whole Body Reaction Timer (Takei Instruments) was used. The instrument consists of 6 plates connected to each other by a cable circuit. The two plates are located in the center where the practitioners were placed. The other four plates are located on the right, left, front and back of the center plates. The practitioners reacted to visual stimulus that was present on a screen at a distance of 3m indicating one of the four directions. When the stimulus appeared, the practitioners had to move to the corresponding plate as fast as they could. The evaluated variable was the mean reaction time (sec) of a total of 16 attempts (four in each direction). The reliability of the test was *r*= .93.

2.5 Statistical Analysis

To perform analyses of the study's data, the SPSS 23.0 (Statistical Package for the Social Sciences) for Windows was used. One way analysis of variances (One-Way ANOVA) conducted to evaluate the initial differences in WBRT of the participants of the three groups at pre –test. Two-Way Analysis of Variances with repeated measures (Two-Way Repeated) was conducted to assess the effect of training programs and measurements across time on WBRT performance. The dependent variable was WBRT test scores. The within-individuals' factors were Training program groups with three levels (FIVE, TT and CG) and Time with three levels (pre, post and one –month retention test). Significant differences between the means across time were tested at the 0.05 alpha level. An effect size was computed for each analysis using the eta-squared statistic (η^2) to assess the practical significance of findings. Cohen's guidelines were used to interpret η^2 effect size: 0.01=small, 0.06=medium and 0.14=large (Cohen, 1988). The hypotheses of this study were:

(H1) The three groups of children will not differ significantly on measure of WBRT at pre-test.

(H2) The children in both experimental groups would improve and retain their performance on WBRT, in contrast with those in the CG.

3. Results

One-way analysis of variance (One –Way Anova) was conducted to evaluate Hypothesis I (that the three groups of participants would not differ significantly on measure of WBRT at pre-test). Indeed, there were no significant initial differences between the three groups in the mean WBRT test scores, $F_{(2,45)}=1.303$, $p>.05$.

Two-way analysis of variances with repeated measures (Two –Way Repeated) was conducted to evaluate the Hypothesis II (those participants in both the FIVE and the TT groups would improve and retain their WBRT, in contrast with those in the CG). As demonstrated in what follows, this hypothesis was corroborated. The results of the present study revealed that, regardless of whether it was FIVE or TT group, WBRT improved and retained in contrast with CG (Table1).

Table 1: Pre, Post and Retention Tests in WBRT (mean ± SD).

		Pre –test		Post –test		Retention –test	
		Mean	SD	Mean	SD	Mean	SD
WBRT	FIVE	0.67	0.12	0.63	0.10	0.57	0.10
	TT	0.75	0.15	0.61	0.12	0.55	0.13
	CG	0.71	0.14	0.66	0.10	0.68	0.10

Note: SD: Standard Deviation

There was not noted significant main effect on WBRT, $F_{(2,45)}=2.117$, $p>0.05$, partial $\eta^2=0.086$, while the training programs × mean of WBRT interaction effect was significant, $F_{(2,44)}= 12.062$, $p<0.05$, partial $\eta^2= 0.354$. The univariate test associated with the Group's main effect was also significant as well, $F_{(4,88)}= 3.204$, $p< 0.05$,

partial η^2= 0.127, which means that the differences before and after the intervention depend on the group being examined each time. Analyzing the interaction on the mean of WBRT for each level of the independent variable, a significant effect of the repeated factor Time was found only for the FIVE group, $F_{(2,44)}$= 3.857, p<0.05, partial η^2= 0.149 and the TT group, $F_{(2,44)}$= 13.825, p<0.05, partial η^2=0.386 but not for the CG, $F_{(2,44)}$= 0.981, p> 0.05, partial η^2=0.043. Pairwise comparisons using t-test with a Bonferroni adjustment revealed significant mean differences in WBRT between pre –test and retention test (MD= 578.292; 95% CI: 307.991 to 848.593, p<0.05) and between post –test and retention test (*MD* =0.095, 95% CI: 0.003 to 0.187,) p<0.05) in FIVE group. Similarly, significant mean differences in WBRT were found between pre-test and post –test (MD= 0.139; 95% CI: .0.45 to 0.233, p<0.05) and between pre –test and retention test (MD= 0.198; 95% CI: 0.105 to 0.290, p<0.05) in TT group (Figure 1). In conclusion, the retention WBRT scores test was remarkably higher than pre-test scores for both experimental groups, but not for the CG.

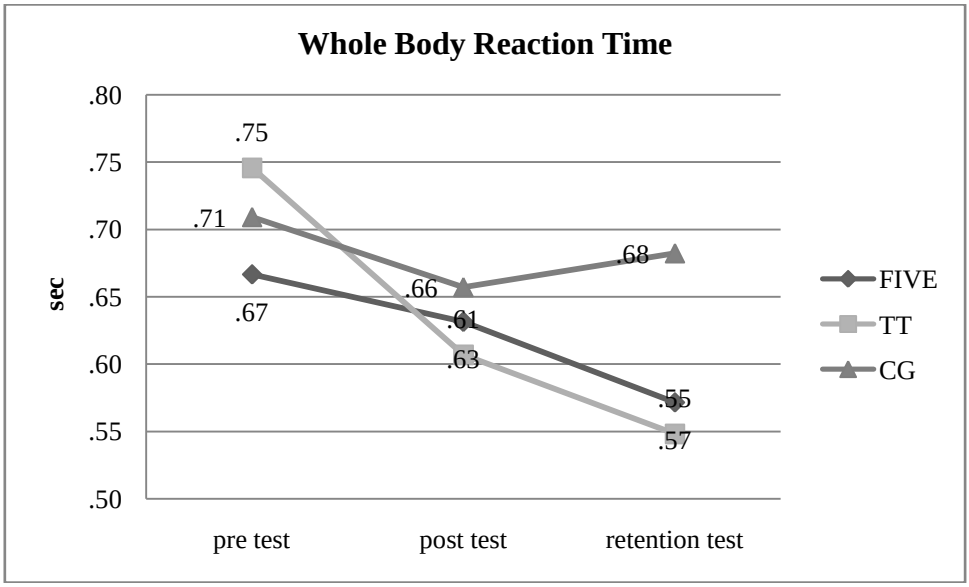

Figure 1: Performance on all measurements across time of the WBRT ability test of the three groups.

4. Discussion – Conclusions

The purpose of this work was to define the effect of two educational interventions, a program based on FIVE games and a TT program, on improvement of WBRT in children aged 8-10 years old. Before, after and one -month after the interventions, the children's WBRT was measured. In particular, the mean reaction time (sec) of a total of 16 attempts (four in each direction) was estimated.

During the training, athletes receive a significant number of stimuli, which they are asked to process in order to react, choosing the appropriate response as quickly as possible (Michalopulu, Tzetzis, Koutlas, Taxildaris, & Kioumourtzoglou, 1994), moving their whole body. Specifically, the special features required for high performance in volleyball (speed and accuracy of response successfully), as the main sources that generate information are the ball, the athlete, teammates and adversaries (Dina, et al., 2013), impose the acquisition of WBRT, as taking part in a sport involves whole body actions that present postural and inertial challenges (Du & Clark, 2018). Hence, there is a need of improving WBRT. The results of this research revealed that WBRT can be developed /improved through exercise, as both experimental groups, FIVE and TT, developed/ improved the WBRT. Considering the above, WBRT can be improved both with FIVE as well as with TT games, where stimuli are many and the practitioner has to react in every stimuli by moving the whole body in the right direction. These results confirm Olivier et al. (2021) who mention that WBRT can be improved trough appropriate exercise. They are also in accordance with Schmidt (1991), who revealed that reaction time can be decreased through exercise, especially when the stimuli and the response options are enough and there is a need to move the whole body, just as happens in WBRT.

This research suggests methods to improve WBRT, providing a useful tool for Physical Education Professionals (PEP) and coaches in order to improve WBRT in a different way. Except of typical training that all PEPs and coaches use in order to train this so crucial for athletes PA, as well VR could be used in combination with typical training in order to keep on improving WBRT in home to the young athlete. In addition, the use of video games in physical exercise, known as exergaming, has been increasing in attention and popularity in recent years (Sinclair, et al., 2007). Moreover, exergames are workable, potentially effective

and probably could constitute an important and powerful tool available to the PEPs (Merino Campos & Del Fernandez, 2016). Therefore, it is at the discretion to each PEP and coach to use whichever method he or she thinks can support it. For instance, volleyball athletes can develop and retain WBRT that has been found to be necessary for volleyball (Oxendine, 1984; Schmidt & Lee, 2005), through training in the court using specific exercises. In combination with training in the court, athletes can continue practicing in WBRT in an enjoyable and safe environment (Huang, Wong, Lu, Huang, & Teng, 2017) by playing these specific games in PlayStation VR. It could be suggested as an alternative method of practicing WBRT. Consequently, athletes could practice WBRT at home in an enjoyable way (Faric, et al., 2019), and without risk of injury (Huang, et al., 2017). Perhaps this tool could be used during periods of home confinement, as we lived due to COVID-19, where children have to stay away from the court and both PEPs and coaches were looking for ways to keep somewhat or better to improve PA. Besides, sports coaches, performers and scientists are constantly in search of new means to enhance sports performance and gain a competitive advantage (Abernethy & Wood, 2001).

In addition, the fact that the FIVE group improved WBRT, consists a very important point of the research and contributes to its innovation, as in the existing literature the FIVE have not been used in the development/ improvement of WBRT in order to exist indications of their impact. Future research should be conducted (possibly in younger or older children) to determine if FIVE exergames can improve other PA, such as depth perception or selective attention. Also, the same research should be conducted in young athletes of individual or other team sports.

5. References

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