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Video Games in the Treatment of Amblyopıa: A Narrative Review

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***Abstract*—Background: Amblyopia can drastically affect a child's life. Recently, following a shift in the view of amblyopia from that of a monocular disorder to that of a binocular disorder, dichoptic video games were introduced as a new treatment method.**

Aim: To explore the role of video games in the treatment of children with amblyopia.

Methods: PubMed and Google Scholar were screened for the keywords "amblyopia" and "games", from January to March 2022. Only articles written in English that discussed video games for the treatment of amblyopia were included.

Results : The advantages of dichoptic video games include a more rapid improvement in visual acuity in different age groups, simpler compliance monitoring, and possibly a reduced risk of recurrence. However, not all studies proclaimed the effectiveness of video games and some raised concerns about their addictive potential.

Conclusion : Dichoptic video games require further controlled studies to demonstrate their efficacy. However, they show promising results in the treatment of what was, until recently, considered untreatable amblyopia.

***Index Terms*—Amblyopia, Video Games, Dichoptic**

I. INTRODUCTION

Amblyopia (lazy eye) affects children worldwide. Its prevalence varies, with a pooled estimate of 1.75%, ranging from 3.67% to 0.51% [1]. It is important to manage this disorder early, as it could cause unilateral visual impairment [1]; it might also affect stereopsis and hence reduce fine and motor skills [2]. An impact has also been noted on children's psychological wellbeing [2]. Children who grew up with amblyopia were less likely to complete a high university degree and were three times more likely to develop a visual impairment in the better-seeing eye than those without amblyopia [3].

Following refractive correction, the standard treatment for amblyopia consists of either patching, atropine drops, or Bangerter filters [4]. These methods target the monocular visual acuity deficit by occluding or blurring the better-seeing eye and consequently forcing the amblyopic eye to work.

Several new treatments are still under investigation, including dichoptic video games and movies which work by targeting binocular dysfunction and interocular suppression in both eyes. These treatments were developed following a shift in the view of amblyopia from a that of a monocular disorder to that of a binocular disorder [5]. The use of video games in the treatment of amblyopia goes back as far as 2006, when the Interactive Binocular Treatment (I-BiT^{TM}) system was first introduced [6]; nonetheless, whether such new treatment is equal to the standard treatment has not yet been affirmed. This review, therefore, aims to explore the role of video games in the treatment of children with amblyopia.

II. METHODS

PubMed and Google Scholar were screened for the keywords "amblyopia" and "games", from January to March 2022. Included were observational and interventional studies as well as reviews. The results were limited to publications in the English language (Figure 1).

III. RESULTS

A. Approaches for the use of video games in treating amblyopia

There are three approaches when using video games to treat amblyopia: The first uses patching

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combined with video games; the second is video games designed to improve stereopsis; and the third is video games with dichoptic viewing [7].

The first approach revealed a significant improvement in patients who played action and non-action video games for 40 hours with the better-seeing eye patched [8]. The study recruited both teens and adults.

The second approach saw the development of a virtual game to target stereopsis. Called Bug Squashing Game, it aimed to reduce suppression and improve stereoacuity, both of which aims were achieved among adults with anisometropic or strabismic amblyopia or pure strabismus [9].

Dichoptic games are a form of binocular therapy that has been introduced as a new treatment modality for amblyopia. The concept of binocular therapy is that the same image is presented to both eyes, but with differing contrast. The amblyopic eye will be exposed to a high-contrast image, and the reverse for the non-amblyopic eye [4]. This method rebalances the signals between the eyes, thereby reducing the suppression and leading to the simultaneous use of both eyes. Although such approach is still under investigation, it has shown some promising results that might encourage further research.

Some advocate for the inclusion of dichoptic movies as part of dichoptic treatment [5]. A study compared dichoptic stimulation from video games with that from movies in children aged 4–8 years. It found that visual acuity significantly improved in both groups, with no difference in effectiveness between the groups. Since more attention is directed toward dichoptic video games, this review will elaborate more on such approach.

B. Variables impacting the efficacy of dichoptic video games

There are several factors that might influence the efficacy of dichoptic video games in the treatment of amblyopia and, in turn, the improvement in visual acuity. These include the patient's age, compliance, and the number of treatment hours.

C. Patient's age

Dichoptic video games have shown to improve amblyopia even in older children and adults, which was previously considered untreatable due to the concept of the "critical period" [2]. Studies evaluating the effectiveness of dichoptic video games included samples from various age groups. Some found significant improvement despite including children over 7 years and adults; an advantage not demonstrated by patching. [5] [10] [11] [12]

For example, one study [11] evaluated children aged 4–12 years after four weeks of intervention. It was noted that those who played binocular games had significant improvement in visual acuity, and that they maintained this improvement for at least three months. However, in another study [13], despite improved visual acuity in the 7–13 age group, such improvement remained significantly better in those under 7 years of age.

Age may therefore be an important predictor of the outcome of video games as a treatment, but the encouraging results of improved visual acuity in older children and adults should not be ignored.

D. Period of intervention

With dichoptic video games, the dose-response relationship was positive; i.e., the more hours played, the better the outcome, up to 10–16 hours of playing, after which no further improvement was noted [11] [14] [15]. With patching, on the other hand, for improvement to be significant, 2–6 hours of daily patching is required (depending on the severity of amblyopia) [4] for a period of at least six weeks, which could be problematic for children with regard to compliance [16].

In one study, an average of 10 hours of video games was compared to an average of 27.7 hours of patching, over a two-week period. The results showed that, compared with patching, video games led to a greater improvement in visual acuity in fewer hours [14].

E. Compliance

Several studies found high compliance, of 50-90%, in children playing dichoptic video games [14][15] [17]. However, this was not the case in all of the studies, as some reported a low compliance rate. In one controlled trial [13] only 22% of children achieved more than 75% compliance, and

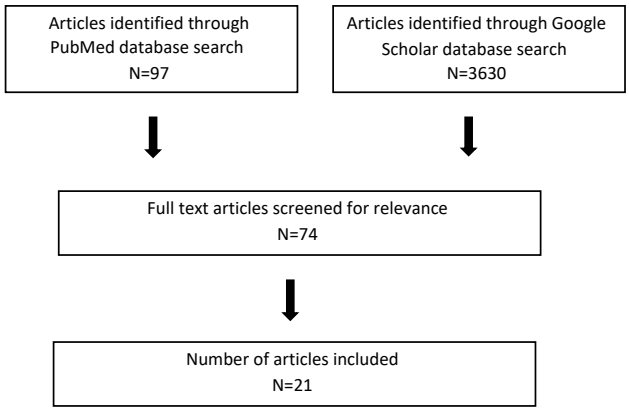

Figure 1. The search strategy used in this review

the investigators also noticed that the children lost interest in the game over time.

In another study, compliance was less than 25% in 24% of the children, and in yet another analysis, 10% of the children assigned to the dichoptic games dropped out of the study due to lack of interest [11]. On the other hand, compliance with patching is lower than 50%, making compliance one of the major issues with traditional patching. Multiple patient factors contribute to this low compliance, including prolonged treatment, studying, having to wear the patch on weekends, social stigma, and difficulty for parents in monitoring compliance. [5] [18] [19]

F. Drawbacks to the use of dichoptic video games in treating amblyopia

1) Recurrence: Although video games have been shown to improve visual acuity with no recurrence for one to three months after the study intervention [11] [20], this period is short and might not reflect the real outcome. For instance, recurrence after patching was seen in 25% of patients one year after cessation of successful patching [21]. Further studies are required to assess the long-term risk of recurrence of amblyopia following treatment with dichoptic video games.

2) Adverse events: Adverse events caused by dichoptic video games were not frequent, but they included asthenopia (4%) in one study [22], and double vision (diplopia) in the following studies (16% and 3.8% respectively) [13] [17]. Finally, another study found new deviation and/or worsening of a pre-existing deviation (8.8%) [13].

IV. DISCUSSION

Recent times have witnessed the growth of the gaming industry, and there are many aspects that make video gaming a possible treatment modality for amblyopia; for example, attractive graphics, diverse tasks requiring visual focus, and rewards for successful completion of tasks [23]. Patching has been used for a long time and has proven efficacy in improving visual acuity in children [24] by decreasing the neural signals from the better- seeing eye [4]. However, dichoptic video games as a treatment for amblyopia appear superior when compared with patching. Video gaming addresses the new pathophysiological view of amblyopia as a binocular disorder; moreover, it shows improvement in different age groups, requires simpler compliance monitoring, and shows a possible reduction in recurrence. However, not all studies proclaim the effectiveness of video games in treating amblyopia, and some concerns have been raised about the potentially addictive effect of video gaming on children.

Although video games appear a promising tool to treat amblyopia, they still require further assessment and controlled studies to prove their efficacy. Despite expectations, not all studies found video games to be an effective treatment [25], while others found it effective but not as effective as patching [13] Furthermore, those studies that have already been conducted might not reflect the effect of video games alone, since some children were treated using video games with concurrent patching at a different time of the day [15] [20] [26]. Moreover, upon closer investigation, it appears that video games may not be equally enticing to all children. This raises a question as to the extent to which these video games appeal to children, and how that affects their compliance with treatment and therefore their outcome. As an example, a study [26] evaluated the effect of two binocular games (‘Snake’ and ‘Falling Blocks’) on amblyopic children. The results showed improved visual acuity from both games, but more so from ‘Falling Blocks.’ Hence, the type of game should be taken into consideration when conducting future studies. Finally, while taking into consideration the games’ attractiveness and engagement to enhance compliance, it should also be borne in mind that the features that make video games appealing are the same features that make them potentially addictive. In the fifth edition of the Diagnostic and

Statistical Manual for Mental Disorders (DSM-5), Internet Gaming Disorder is included in Section III as a condition warranting more research before being considered for inclusion in the manual [27].

V. CONCLUSION

Dichoptic video games show promising results in the treatment of what was, until recently, considered untreatable amblyopia in older children and adults. These games also produce faster improvement in visual acuity when compared with patching, and are a more enjoyable approach for patients.

However, further controlled studies are necessary in order to include dichoptic video games as a standard, stand-alone treatment or as an adjunct to patching.

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