

ORIGINAL ARTICLE

THE EFFECTIVENESS OF THE DOT CARD THERAPY TOWARDS CONVERGENCE INSUFFICIENCY PATIENTS AMONG YOUNG ADULTS

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ABSTRACT

Convergence insufficiency is a common binocular vision disorder. It has been reported that the frequency of this anomaly has reached as high as 6% among school children and young adults and may affect their quality of life and near work performance. One of the treatment modalities is the Dot Card therapy. However, there is scarce research report on the effectiveness of the Dot Card therapy. Hence, this study was conducted to compare the effectiveness of the therapy given to convergence insufficiency patients among young adults. A total of 33 university students (age range=22.55±1.66 years) with convergence insufficiency problems participated in this study. Convergence insufficiency symptoms based on the Convergence Insufficiency Symptom Survey (CISS) and binocular vision components such as near point of convergence, fusional vergence and phoria were measured before and after the Dot Card therapy was given to each participant. All participants were reviewed after 2 weeks and 4 weeks. The results indicated that participants demonstrated statistically and clinically significant changes and improvement in symptom from CISS score (22.30 to 15.30, $p<0.001$), NPC (11.08 cm to 6.50 cm, $p<0.001$) and PFV at near (13.82Δ to 18.36Δ, $p=0.035$) at the end of 4-week visit. Participants' near phoria were improved (2.12 exo to 1.79 exo, $p=0.369$) even though it is not statistically and clinically significant. The convergence insufficiency patients have achieved significant improvements in symptoms and near point of convergence both statistically and clinically, within one month of the Dot Card therapy treatment.

Keywords: convergence insufficiency, Dot Card, vision therapy, effectiveness, young adults

INTRODUCTION

Convergence insufficiency (CI) is a common binocular vision disorder which was found affecting up to 6% of population¹⁻⁴. It is often associated with symptoms including asthenopia, ocular discomfort, headache, blurred vision, diplopia, sleepiness, difficulty in concentrating while performing near work and the tendency to lose attention and comprehension after short periods of near activities. The rising CI prevalence and symptoms among children and adult population who constantly having high near work demand^{5,6} and increased electronic screen time⁷⁻⁸, are among the reasons why it is important to have a most effective treatment plan for them. This is because CI may affect one's daily near activities such as reading, computer work, studying and consequently affecting their quality of life^{5,9}.

Convergence insufficiency is determined clinically by receded near point of convergence (NPC), with at least an additional defective clinical findings, either low direct or indirect positive fusional vergence (PFV), greater exophoria at near than distance or low accommodative

convergence/accommodation (AC/A) ratio^{4,5}. Symptoms of CI in patients are measured and recorded using the Convergence Insufficiency Symptom Survey (CISS). The CISS is a validated survey as a primary outcome measure tool to quantify the severity of symptoms in CI patients¹⁰ and has been widely used in previous studies^{5,11,12}. It consists of 15 questions with a 5-point response scale (never, infrequently, sometimes, fairly often, and always). The lowest probable score is zero and the highest is 60. The cut-off score for symptomatic CI is more than 21 for young adults (see Appendix 1 for the CISS)¹⁰.

There is no mutual agreement among all eye care professionals regarding the best treatment for patients with CI. In a survey regarding the prescribing patterns for CI patients among both optometrists and ophthalmologists, it has been reported that the commonly prescribed treatments were base-in prism, pencil push-up therapy (PPT), near reading glasses, home-based vision therapy (HBVT), which includes the Dot Card therapy (DCT) and office-based vision therapy/orthoptics (OBVT)^{9,12-16}.

The DCT is an eye exercise prescribed to CI patients to improve the coordination of eye muscles for both eyes. It consists of seven dots placed at 3cm intervals along a firm card and is used lengthwise with the end of the card touching the patient's nose tip¹⁶. It is said that the DCT is more effective than a simple PPT because it ensures correct ocular alignment during the treatment¹⁶. Even though the DCT is widely prescribed in optometric and orthoptics practices as part of home-based vision therapy, there are very scarce scientific studies to support the effectiveness of the treatments given⁹. As a result, the real effectiveness of this therapy is unknown. Therefore, this study aims to investigate the effectiveness of the DCT treatment to patients with CI problems among young adults.

MATERIALS AND METHODS

This was an experimental and prospective study conducted in Optometry Clinic, Faculty of Health Sciences, Universiti Kebangsaan Malaysia from September 2016 until June 2017. Informed consent was obtained from the participants after explaining the nature and possible consequences of the study. The protocol and informed consent forms were approved by Universiti Kebangsaan Malaysia (UKM) Ethical Committee for medical research (Approval no.: UKM PPI/111/8/JEP-2017-157).

Participants

Thirty three university students aged between 18 to 30 years (22.55 ± 1.66 years) in Klang Valley area participated in this study. Informed consent has been obtained from all participants and they were briefed on the examination process.

Eligibility Criteria

Participants who fulfilled the following criteria were recruited:

Symptomatic or non-symptomatic patients with CI and at least remote NPC break point measured with

accommodative target, which exceeds 7 cm along with additional one or more criteria as stated below:

- (1) Exophoria greater at near than at distance by at least 4 prism dioptre (orthophoria or low exophoria at distance), measured using prism cover test, Maddox Rod and Maddox Wing (for distance and near respectively).
- (2) Insufficient PFV to meet visual demand, measured with step vergence using horizontal prism bar.
- (3) Low calculated AC/A ratio ($< 3:1$).

Exclusion Criteria

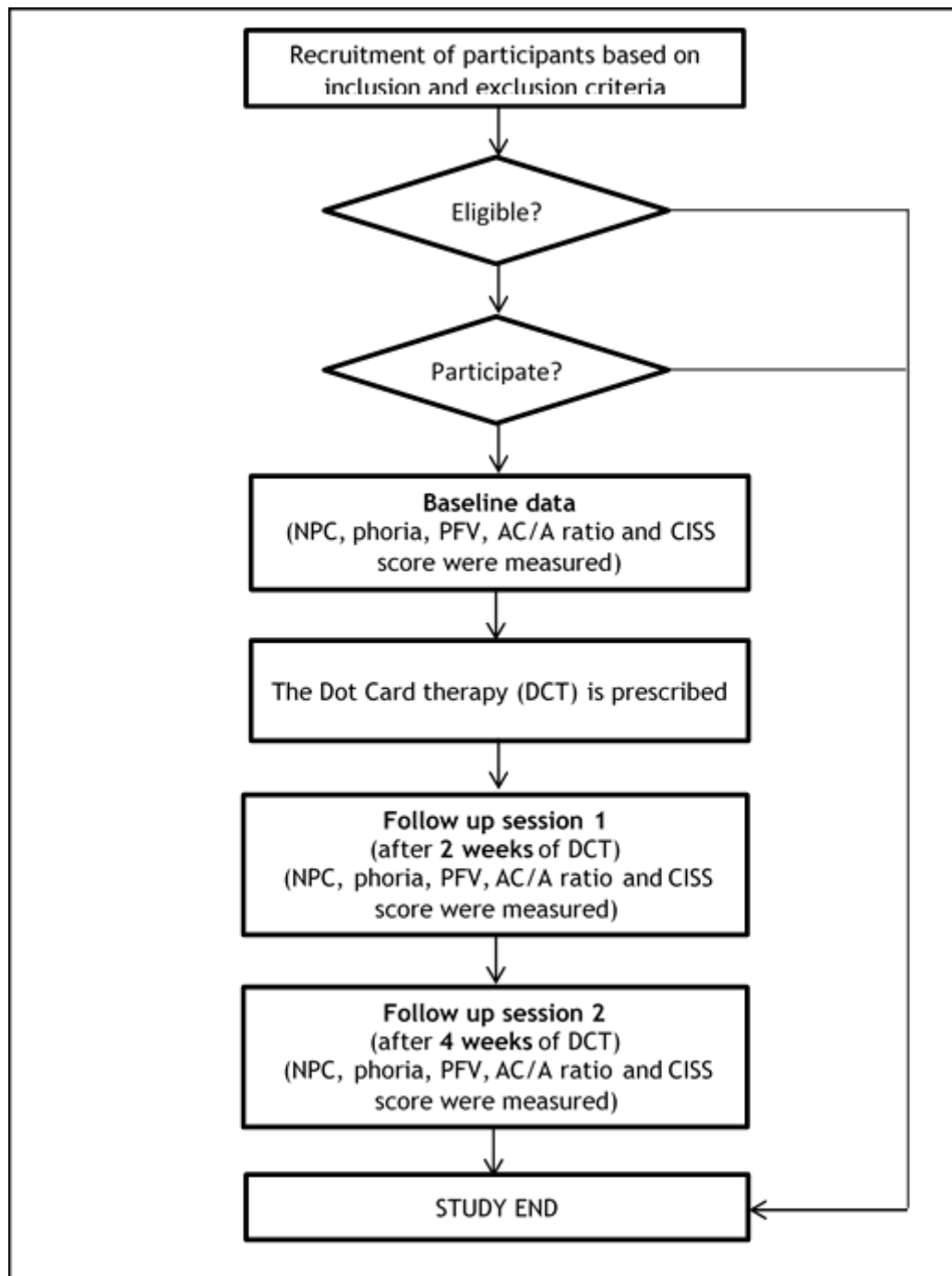
Participants with the criteria below were excluded:

- (1) CI previously treated with any form of vision therapies or treatments
- (2) History of strabismus surgery
- (3) Prior refractive surgery
- (4) Systemic diseases known to affect vergence, accommodation and ocular motility

Procedures

First, eligibility testing in the form of vision screening was carried out to identify eligible participants who fulfilled the inclusion criteria. All participants who undergone the vision screening were with their optimum refractive correction and visual acuity. The clinical parameters were recorded for the pre-test record (before the DCT is prescribed), after 2 weeks and 4 weeks on the therapy. The clinical parameters measured were the NPC, phoria, PFV and the AC/A ratio. All participants were also required to fill in the Convergence Insufficiency Symptom Survey (CISS), before the DCT is prescribed (pre-test record) and consequently after all visits (post-test records) to document the symptoms they may experience throughout the treatment, as detailed in Figure 1.

Figure 1: *Flowchart of the research procedures*



Data Analysis

All data obtained were analysed using IBM SPSS Version 21.0¹⁷. Descriptive analyses of demographic variables were performed. Repeated measures ANOVA were being carried out in order to analyse changes in mean score of each parameter over the 3 time points (at baseline, after 2 weeks of therapy and after 4 weeks of therapy). A p-value of <0.05 was considered statistically significant.

RESULTS

A vision screening has been carried out to 70 university students. Out of this, a total of 33 eligible participants with age ranged between 20 to 28 years old (22.55 ± 1.66 years) were enrolled in this study. There were 88% female and 12% male. 70% of the participants were Malay, 24% were Chinese and 6% were Indian. The results of the measured parameters are as stated in Table 1:

Table 1: Results of parameters measured at baseline, after 2 weeks of therapy and after 4 weeks of therapy.

Parameters	Baseline (mean \pm SD)	After 2 weeks (mean \pm SD)	After 4 weeks (mean \pm SD)	Reference data (normative value)
Mean (SD) CISS score	22.55 (1.66)	18 (9.63)	15.30 (9.54)	Less than 21
Mean (SD) Near point of convergence (cm)				
Break	11.08 (3.76)	8.14 (3.06)	6.50 (1.33)	5cm
Recovery	14.70 (6.09)	11.03 (4.21)	8.85 (2.09)	7cm
Mean (SD) Amplitude of accommodation (D)				
Right eye, OD	9.12 (1.79)	9.70 (1.88)	9.96 (1.78)	10.1 D to
Left eye, OS	9.31 (1.91)	9.74 (1.79)	9.92 (1.80)	12.5 D*
Both eyes, OU	10.27 (2.29)	10.58 (2.08)	10.82 (2.06)	
Mean (SD) Phoria (Δ)				
Distance	0.97 exo	1.30 exo	1.39 exo	1 PD exo
Near	(2.60)	(3.34)	(3.61)	(± 2 PD)
	2.06 exo	1.70 exo	1.79	3 PD exo
	(3.17)	(2.46)	exo(2.37)	(± 3 PD)
Mean (SD) Near positive fusional vergence (Δ)				
Break	13.82 (7.26)	15.58 (6.93)	18.36 (9.55)	21 PD
Recovery	9.79 (6.23)	10.61 (5.37)	13.55 (7.64)	13 PD
Mean (SD) AC/A	5.80 (1.18)	5.96 (1.60)	6.1 (1.29)	4/1 (± 2 PD)

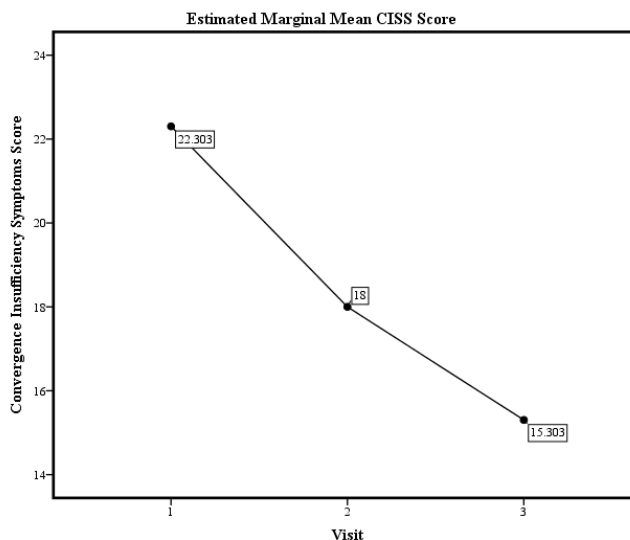
SD= standard deviation; cm= centimetres; D= dioptre; Δ = prism dioptre

* Based on Hofstetter's formula (average expected amplitude) calculated for participants' age range.

CISS Score

At baseline, the mean (SD) of CISS score was 22.55 (± 1.66). A repeated measures ANOVA with sphericity assumed showed that mean CISS score differed significantly between the visits [$F(2, 64) = 9.12, p < 0.001$]. Post hoc tests using the Bonferroni

correction revealed that CISS score reduced by an average of 4.30 ± 1.56 after 2 weeks ($p=0.03$) and then reduced by an additional 2.70 ± 1.51 between 2 weeks and 4 weeks ($p=0.248$). The rate of improvement is 31.39% compared to baseline. The changes in the CISS score is depicted in Figure 2.

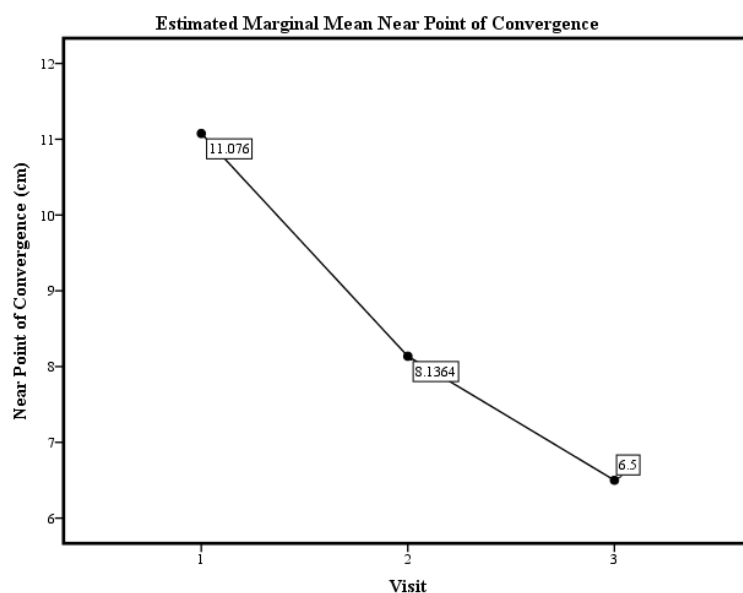
Figure 2: Changes in the CISS score after 2 weeks (visit 2) and 4 weeks (visit 3) of the Dot Card therapy

Near Point of Convergence

At baseline, the near point of convergence break point was 11.08 ± 3.76 cm. A repeated measures ANOVA with sphericity assumed showed that mean near point of convergence break point differed significantly between time points [$F(2, 64) = 40.89$, $p < 0.001$]. Post hoc tests using the Bonferroni

correction revealed that near point of convergence reduced by an average of 2.94 ± 0.51 cm after 2 weeks ($p < 0.001$) and then reduced by an additional 1.64 ± 0.43 cm between 2 weeks and 4 weeks ($p = 0.002$), as in Figure 3. The rate of improvement is 41.34% compared to baseline.

Figure 3: Changes in the near point of convergence after 2 weeks (visit 2) and 4 weeks (visit 3) of the Dot Card therapy

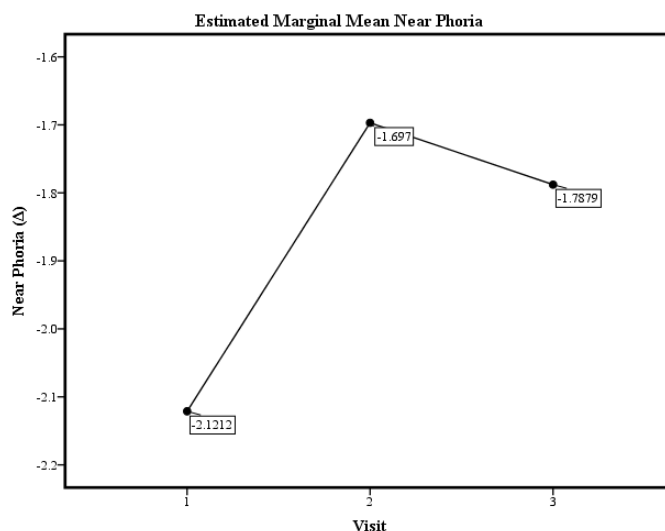


Near Phoria

At baseline, the mean phoria at near was $2.06 \text{ exo} \pm 3.17$ PD. A repeated measures ANOVA with sphericity assumed showed that mean phoria at near differed insignificantly between time points [$F(2, 64) = 1.01$, $p = 0.369$]. Post hoc tests using the Bonferroni correction revealed that phoria at near

reduced by an average of $0.42 \text{ exo} \pm 0.33$ PD after 2 weeks ($p = 0.61$) and then showed a slight increment of $0.09 \text{ exo} \pm 0.27$ PD between 2 weeks and 4 weeks ($p = 1.00$). Despite the slight increment, the rate of improvement is 16.02% compared to baseline as shown in Figure 4.

Figure 4: Changes in the phoria at near after 2 weeks (visit 2) and 4 weeks (visit 3) of the Dot Card therapy

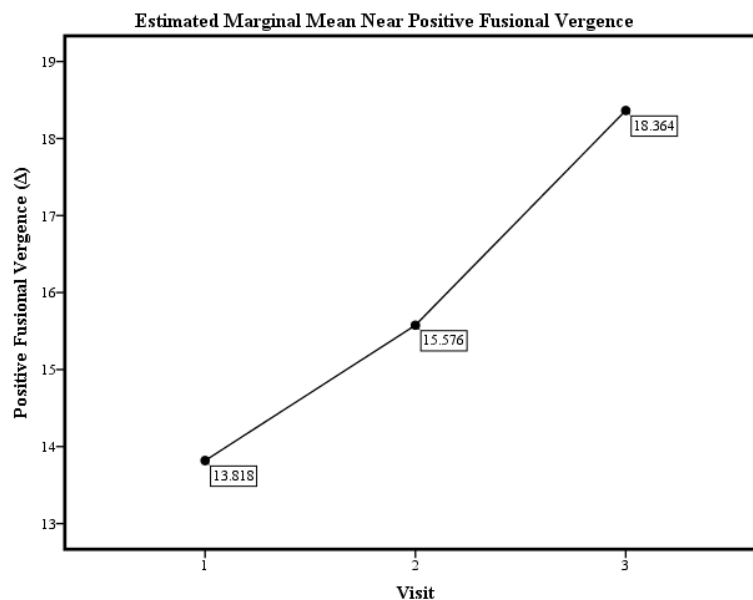


Near Positive Fusional Vergence

At baseline, the entering mean PFV at near was 13.82 ± 7.26 PD. A repeated measures ANOVA with Greenhouse-Geisser correction showed that mean PFV at near differed significantly between time points [$F(1.34, 42.96) = 4.22, p=0.035$]. Post hoc

tests using the Bonferroni correction revealed that PFV at near increased by an average of 1.76 ± 0.92 PD after 2 weeks ($p=0.19$) and then increased by an additional 2.79 ± 1.68 PD between 2 weeks and 4 weeks ($p=0.32$) as represented in Figure 5. The rate of improvement is 32.92% compared to baseline.

Figure 5: Changes in the positive fusional vergence at near after 2 weeks (visit 2) and 4 weeks (visit 3) of the Dot Card therapy



Compliance

To assess participants' compliance, the therapy schedule record was reviewed. Overall, 63.64% of participants practiced this therapy for at least 15 days of the 4 weeks. However, only 2 participants (6.06%) completed this 30-day therapy successfully as suggested. On average, each participant would tend to skip the therapy for at least once a week. Generally, most of the participants showed better compliance after the second visit.

DISCUSSION

Within 2 weeks after this DCT was prescribed, it was found that there were statistically significant changes and clinically relevant improvements in CISS score. At the end of the therapy, an average reduction of symptoms CISS score from 22.3 ± 9.36 to 15.30 ± 9.54 was demonstrated. One of the participants even reported total elimination of symptoms previously had. 75.76% of participants manifested decline in frequency of symptoms occurrence (less than 21 score) after undergoing the therapy plan, as compared to their first visit. About 75.76% of our participants displayed a successful outcome as they were reported of having fewer symptoms after this therapy. Generally, the downtrend of CISS score was gradual and significant

during each visit¹². Past research has also proven the effectiveness of orthoptics exercise in reducing symptoms, regardless whether it was done on adults or children population^{5,11,12,18}. The Convergence Insufficiency Treatment Trial (CITT) Study Group has also defined a CISS score of <21 a successful outcome for a CI treatment⁵.

However, about 24.24% participants exhibited increment in terms of symptoms frequency at the end of this study. This could be due to the different demand of near work involved in participants' daily routine within the 4 weeks of the course of this research study. It is reasonable that one may have dissimilar responses if they were to evaluate experiences of symptoms while their visual systems are under state of stress¹. They may also experience non-visually related symptoms which might mimic the visual symptoms as in CISS, hence turned out to remain symptomatic even after the therapy¹⁹. Even so, based on verbal feedbacks from participants, all of them experienced noticeable reduction in symptoms as compared to their first visit, before they started the prescribed DCT.

Meanwhile, it was also found that there were statistically significant changes and clinically relevant improvements to normal clinical values in NPC. Similar finding was also being reported with

the application of office-based vision therapy/orthoptics among young adults with symptomatic CI. Although the type of therapy given was different, both therapies were designed to normalize both accommodative system and vergence¹².

More emphasis was placed on investigating the PFV system at near among participants, rather than the negative fusional vergence system as the demand on binocular system for the exophoric patients. Hence, it was aimed to determine if there is any improvement in positive fusional reserve in order to compensate for exophoria at near. It was found that there are significant changes in PFV at near among participants from $15.58 \pm 6.93\text{PD}$ to $18.36 \pm 9.55\text{PD}$ at the end of 4 weeks therapy session. According to previous study, PFV value lower than 15PD would be considered abnormal for patients with CI and also the general population²⁰. In addition, low PFV is normally associated with asthenopic symptoms among patients²⁰. As a result, it can be said that the reduction in symptoms experienced by participants in this study could be correlated to the improvement in their PFV at near throughout the therapy¹².

Most of the participants claimed that they did not record all therapy sessions done. As a result, the actual documentation and analysis on participants' compliance could not be performed. According to participants' recording sheets, 63.64% of them carried out the therapy at least 15 days within a month. Nevertheless, most participants have shown overall improvement.

Limitations

In this study, participant selection mainly focused on the young adults in their university's study year in Klang Valley area with a pre-determined calculated sample size of 33. Different outcomes may have resulted if a larger sample size was obtained. Due to time constraints, the duration of therapy was being limited to 4 weeks. It is possible that a lengthened period of therapy may have produced different results or additional changes in both signs and symptoms.

Since participants involved were university students in their active semester with different visual activities, we did not control each participant's near work demand. Furthermore, physiological changes which varies in each individual at different time points could have contribute to the symptoms and signs for their CI problem. Future study should consider these factors and involvement of a control group may help to investigate further.

CONCLUSIONS

Based on the results in this study, the DCT could significantly improve the symptoms and NPC values for CI patients as early as 2 weeks into treatment. Less exophoric finding and increment in PFV range at near were also documented. Thus, the DCT may be used in clinics or as a home-based therapy to improve symptoms and binocular vision parameters for convergence insufficiency patients.

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REFERENCES

1. Rouse MW, Borsting E, Hyman L, et al. Frequency of convergence insufficiency among fifth and sixth graders. *Optom Vis Sci* 1999; **76**(9): 643-649.
2. Porcar E, Martinez-Palomera A. Prevalence of general binocular dysfunctions in a population of university students. *Optom Vis Sci* 1997; **74**:111-113.
3. Scheiman M, Gallaway M, Coulter R, et al. Prevalence of vision and ocular disease conditions in a clinical pediatric population. *J Am Optom Assoc* 1996; **67**(4): 193-202.
4. McGregor, ML. Convergence insufficiency and vision therapy. *Pediatric Clinics* 2014; **61**(3): 621-630.
5. Convergence Insufficiency Treatment Trial Investigator Group. A randomised clinical trial of treatment for symptomatic convergence insufficiency in children. *Arch Ophthalmol* 2008; **126**(10): 1336-1349.
6. Azmi H, Mohd Kamil H, W Fadillah WH. Tekanan Kerja dan Masalah Kesihatan di Kalangan Pengguna-Pengguna Komputer di Jabatan Kesihatan Negari Terengganu. *Malaysian Journal of Public Health Medicine* 2002;**2**(1):13-20.
7. Suria J, Amar-Singh HSS, Azaliah I, et al. Electronic Screen Time of Two-Year-Old Children in Malaysia [abstract]. *Malaysian Journal of Public Health Medicine* 2016;**16**(Suppl 4):P29.
8. Mathew P. Excessive screen time strains children's eyes. 2017. Gulf News. <http://gulfnews.com/better->

- health/lifestyle/excessive-screen-time-strains-children-s-eyes-1.2098960 (accessed 7 November 2017).
9. Scheiman M, Cooper J, Mitchell L, et al. The convergence insufficiency treatment trial: design, methods, and baseline data. *Ophthalmic Epidemiol* 2008; **15**: 24-36.
 10. Rouse, M, Borsting, E, Mitchell, GL, et al. Validity of the Convergence Insufficiency Symptom Survey: A Confirmatory Study. *Optom Vis Sci*; 2009; **86**(4): 357-363.
 11. Horwood, AM, Toor, S, & Riddell, PM. Screening for convergence insufficiency using the CISS is not indicated in young adults. *British Journal of Ophthalmology*; 2014; **98**(5): 679-683.
 12. Scheiman M, Mitchell GL, Cotter S, et al. A randomized clinical trial of vision therapy/orthoptics versus pencil push ups for the treatment of convergence insufficiency in young adults. *Optom Vis Sci* 2005; **82**(7): 583-595.
 13. Scheiman M, Cooper J, Mitchell L, et al. A survey of treatment modalities for convergence insufficiency. *Optom Vis Sci* 2002; **79**(3): 151-157.
 14. Darko-Takyi C, Asiedu K. Symptomatic classic convergence insufficiency treated with dot card orthoptic exercise. *Optometry Reports*; 2016; 5: 5566.
 15. Lavrich, Judith B. Convergence insufficiency and its current treatment. *Curr Opin Ophthalmol* 2010; **21**(5): 356-360.
 16. Wrightington, Wigan and Leigh NHS Foundation Trust. Home exercises to improve convergence insufficiency: Patient Information [manual] 2016; 3-5.
 17. IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.
 18. Westman M, Liinamaa MJ. Relief of asthenopic symptoms with orthoptic exercises in convergence insufficiency is achieved in both adults and children. *J Optom* 2012; 5: 62-67.
 19. Bade A, Boas M, Gallaway M, et al. Relationship between clinical signs and symptoms of convergence insufficiency. *Optom Vis Sci* 2013; **90**(9): 988-995.
 20. Cooper J, Selenow A, Ciuffreda KJ. Reduction of asthenopia in patients with convergence insufficiency after fusional vergence training. *Am J Optom Physiol Opt* 1983; **60**(12): 982-989.