American Journal of
Biomedical Science & Research

www.biomedgrid.com
ISSN: 2642-1747

Research Article

The Effect of Wearing Pre-Heated Eye Compress Upon Subfoveal Choroidal Thickness (SFCT) in Young, Healthy, Myopic Adults

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To Cite This Article: *Saleh A AlKhaldi* . The Effect of Wearing Pre-Heated Eye Compress Upon Subfoveal Choroidal Thickness (SFCT) in Young, Healthy, Myopic Adults. Am J Biomed Sci & Res. 2024 23(2) AJBSR.MS.ID.003057,* DOI: 10.34297/AJBSR.2024.23.003057

Received: July 08, 2024; **Published:** July 15, 2024

Abstract

Purpose: To investigate the effect of applying external source of heat upon Subfoveal Choroidal Thickness (SFCT) in healthy myopic adults.

Methods: 10 myopic subjects wore pre-heated eye compress for 10 minutes. SFCT was measured using swept source optical coherence tomography before and after they were exposed to the external source of heat.

Results: No significant change in SFCT was found as a result of wearing hot eye compress for 10 minutes in all choroidal areas except for the outer nasal area (p>0.05). However, one subject showed substantial change in all choroidal areas.

Conclusion: Wearing pre-heated eye compress did not substantially affect SFCT except for outer nasal area, while one subject showed substantial change in all choroidal areas which requires further investigation.

Keywords: Choroid, Choroidal thickness, Optical coherence tomography, Light exposure, Outdoor activity, Eye compress

Introduction

The choroid is highly vascularised structure located in the posterior half of the eye. The main function of the choroid is to supply oxygen and nutrients to the outer retina, and also to the inner retina in species with avascular retina [1,2]. The choroid has other important functions such as modulating the temperature of the eye by thermal dispersion, regulating intra ocular pressure by controlling blood flow, and the absorption of stray light in species with pigmented choroids [1,2]. Another important function is the drainage of aqueous humor from the anterior chamber through the uveo-scleral pathway. This pathway is responsible for approximately 35% of the drainage in humans, and a higher percentage of between 40 and 60% in primates, although it can be as low as 3% in rabbits and cats [3].

Several factors affecting CT in human eyes have been reported including refractive error, Axial Length (AL), and diurnal variation. Recent studies in human subjects show a relationship between refractive error and CT, with the choroid being thinner in myopic subjects and thicker in hyperopic subjects [4,5,6]. Furthermore, in myopia of ≤-6.00D extreme choroidal thinning has been observed which may contribute to vision loss and retinal pathology [7,8,9].

There is growing evidence from the literature indicating that the refractive status of the eye might be affected by external factors. Animal studies suggested that ambient light exposure may be an important environmental factor in the regulation of refractive development. Previous studies showed that chicks raised in a normal visual environment with average light intensity and a normal day/

night cycle, had normal eyes development towards emmetropia and show no or minimal changes in the refractive status [10,11]. Other studies show that when chicks are exposed to low intensity of light with a normal circadian cycle, they developed myopia [11]. Furthermore, when chicks were exposed to high intensity of light with a normal circadian cycle, they developed hyperopia [12]. Exposure to high levels of illumination seems to prevent the progression of form deprivation myopia in rhesus monkeys [13] as well as chicks [14,15]. High levels of illumination appear to slow myopia progression induced by negative lenses in chicks [16] In contrast, when myopia was induced by negative lenses in infant monkeys, high levels of illumination had no significant effect on the development of myopia [17].

A number of studies have been conducted to examine the influence of exposure to high levels of illumination in humans. One study examined 101 school children, 41 myopes (-2.39±1.50D) and 60 non-myopes (+0.34±0.30D) measuring AL at four visits over a period of 18 months. The daily light exposure was obtained from light sensors worn on the wrist. The study found a statistically significant relationship ($p<0.05$) between axial eye growth and average daily light exposure, with AL growth being slower in children exposed to a higher overall illumination (1455±317-lux), whereas children who experienced lower levels of daily light exposure (459±117-lux) showed significant increase ($p<0.05$) in axial eye growth [18].

Another study examined 27 healthy myopic adults (MSE=-3.15±2.00D). All subjects were exposed to 150-lux for 4 hours before sleep in the first 2 nights. Subsequently, subjects were exposed to 1000-lux for 4 hours before sleep, on 5 consecutive nights. The results revealed a significant reduction in SFCT from 268±57.10µm in the first 2 nights to 245.00±52.84µm ($p<0.05$) after subjects were exposed to the 1000lux intensity for the subsequent five nights showing that CT can be altered by exposure to bright light in the evening time [19]. At the time of writing paper, a literature search identified no previous work investigating the effect of heat applied externally upon the choroid. The aim of the current study is to investigate the response of the choroid to increased eye temperature induced by heat applied externally to the eye in a group of young, healthy, myopic adults.

Materials and Methods

Ten healthy myopic adults (4 males and 6 females) were recruited from a university population. The age of the participants ranged between 18 and 28 years old (mean±SD=22±3.68years). The group refraction ranged between -1.50D and-5.00D (mean±SD=-2.95±1.10D) with astigmatism of no less than -1.25DC. Subjects who had previous or current ocular pathology, ocular surgery or chronic systemic disease (e.g. diabetes) were excluded. All participants included in the study had best corrected visual acuity of 6/6 or better in both eyes. Nine subjects were Caucasian and one was Hispanic. The experiment was approved by the local Ethics Committee and was conducted in accordance with the Declaration of Helsinki for research involving human subjects and the current guidelines of Good Clinical Practice. All participants completed a consent form and were given information leaflets, after verbal explanation about the nature of the study and any possible consequences.

Instrumentation

Topcon SS OCT: CT was measured using Swept Source Optical Coherence Tomography (SS OCT). The SS OCT (Topcon Inc, Tokyo, Japan) is a new generation of high penetration OCT devices which use a tuneable laser to allow visualisation of ocular layers below the retina [20,21].

Eye Compress: A Bruder MediBeads eye compress (Bruder Health Care Company, Atlanta, USA) was used to apply heat to the eye (Figure 1). This heated compress is recommended in practice to alleviate symptoms of dry eye, Meibomian Gland Dysfunction, and blepharitis. The microbeads within the compress are activated to produce heat by microwave radiation at 800W output power for a duration of 20 seconds. The Bruder eye mask may reach a temperature as high as of approximately 52°C for the first minute after heating and maintains a temperature ~50°C for the first 5 minutes, before slowly cooling [22]. Where the mask feels too hot for the subject, the manufacturers recommend that it should be removed and re-applied one or two minutes later. In addition, the manufacturers state that after removal, subjects might experience blurred vision due to released meibum. Generally, vision returns to normal in a short time [23]. The Bruder eye mask must be tested on patient's eye before fully applying it in order to prevent eyelid burns [24].

Figure 1: It shows the re-usable Medibeads eye compress which can be heated by microwave. The image was taken from Bruder Health Care official website

Measurements of CT

All subjects were examined between 12:00 pm and 2:00 pm in order to avoid confounding factors such as diurnal variation of CT. At the beginning of the experiment, a baseline measurement of CT for the right eye was acquired using the SS OCT (FGA mode). The subject then wore the eye compress for 10 minutes after it was pre-heated as described. A second scan was then obtained immediately upon removal of the eye compress. The temperature of the eye compress was measured directly after heating and at the end of the 10-minute wear period. In addition, eyelid temperature was measured before and after wearing the eye compress. The temperature was measured using infrared thermometer THI-700 (Tasco, Japan). CT measurements was recorded as nine 9 choroidal areas based on the early treatment diabetic retinopathy study (ETDRS grid) as can be seen in Figure 2. These areas are: central foveal area (1mm diameter), inner circle (3mm diameter) and outer circle (6mm diameter), which are divided into four quadrants: superior, nasal, inferior and temporal). The central area of 1mm is defined as the subfoveal choroidal thickness (SFCT) while the 3mm inner circle and 6mm outer circle represent the parafoveal and perifoveal regions respectively [20].

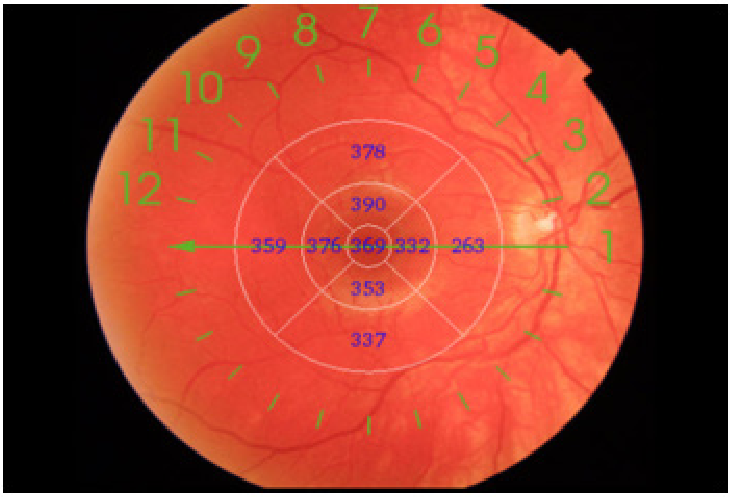

Figure 2: It shows the map of nine choroidal thickness areas based on the ETDRS grid.

Data Analysis

SPSS software version 22 for Windows (SPSS Inc., Chicago, IL, USA) was used to perform statistical analysis for our data (www.ibm.com/software/analytics/spss/). A Shapiro-Wilk test was performed to determine the normality. Since the data is normally distributed (parametric), paired samples t-test was used to analyze the short-term changes in CT before and after wearing the eye mask. Results were considered statistically significant if the p value is <0.05.

Results

The SFCT in the subject group ranged from 218μm to 335μm (mean±SD=267±34.34μm). Table 1 displays the summary of CT measurements (μm) according to ETDRS grid, before and after wearing the preheated eye compress for ten minutes. Values show mean±SD. No significant variation in CT was found as a result of applying heat to the eye and this was the case for 8 ETDRS areas of the choroid ($p>0.05$), except for the outer nasal area ($p<0.05$). It is worth noting however that while the overall change is not significant, every ETDRS area showed an increase in the group mean CT (Figure 3). One subject (Hispanic) showed substantial post-heating increases in CT for all areas due to an increase in external ocular temperature, and these results can be seen in Figure 4. This subject was a girl, 27 years old, and her prescription for the right eye was -3.75DS. The eye compress temperature after activation but before wearing ranged between 49˚C and 54˚C (mean±SD=52.07±2.14), and after wearing ranged between 34˚C and 36.50˚C (mean±SD= 34.50±0.73˚). The eyelid temperature prior to application of the compress ranged between 33˚C and 35˚C (mean±SD=33.68±0.63˚), and upon removal of the compress ranged between 34.50˚C and 36.50˚C (mean±SD=35.28±0.63˚) as shown in Figure 5.

Discussion

The results of the present study show that the application of external heat to the eye produced no significant effect on CT in this myopic subject group, except for the outer nasal area. It is not clear at this point why there is a significant change in this region and further work is required. In addition, one subject shows a clear increase in CT for all the nine choroidal areas after wearing the eye compress. It is notable that while there was no significant group change, there was a tendency for the CT to increase after the application of heat, although the changes tended to be small. This study examined the possibility that CT might be affected by an external source of heat, since the choroid is known to be responsible for regulating temperature and controlling blood flow in the human eye [1,2]. In terms of external heat effect, there was no similar published work could be found in the literature so that we can compare the findings to previous research.

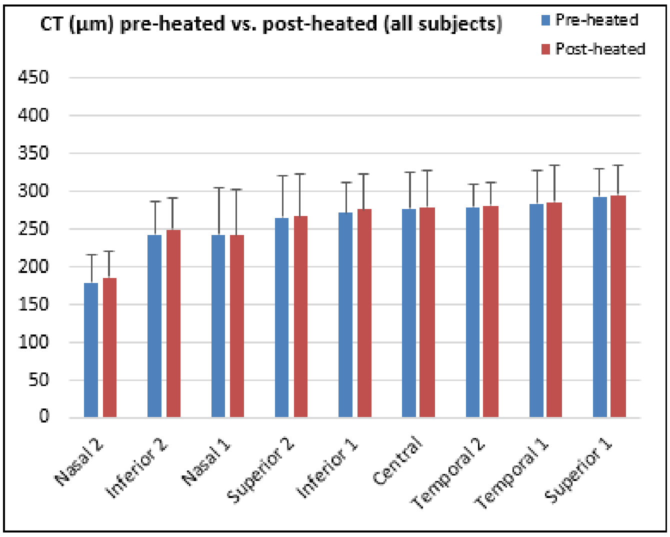

Figure 3: It demonstrates the measurements of CT (all subjects) in all 9 choroidal areas (ETDRS) before and after wearing the preheated eye mask for 10 minutes. Error bars represent SD.

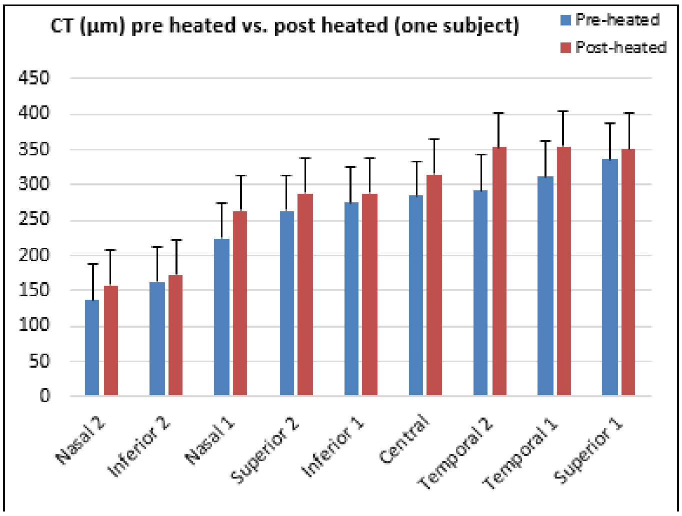

Figure 4: It shows how the CT measurements for one subject changed significantly in all 9 ETDRS areas as a result of wearing the pre-heated eye mask for 10 minutes. The data shows an increase in all CT areas. Error bars represent SD.

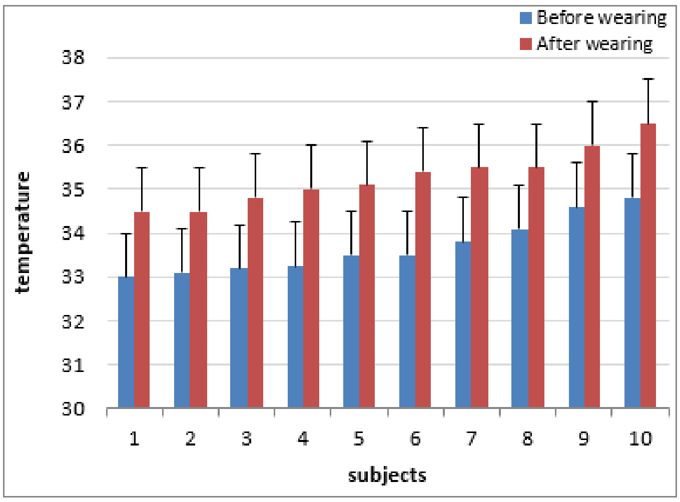

Figure 5: It shows eyelid temperature (Celsius) before and after wearing the pre heated eye mask for 10 minutes. Error bars represent SD.

Table 1: It shows summary of CT measurements in all choroidal areas before and after wearing the pre-heated eye compress.

Choroidal Area (ETDRS)	Pre heated	Post heated	P value
1mm central	277.00±47.63	279.80±48.64	>0.05
3mm superior	293.10±37.52	295.40±39.17	>0.05
3mm nasal	242.60±43.84	249.40±42.75	>0.05
3mm inferior	265.40±55.64	267.20±55.25	>0.05
3mm temporal	283.80±43.02	286.80±48.84	>0.05
6mm superior	279.00±29.83	282.20±30.03	>0.05
6mm nasal	179.10±36.09	185.80±35.79	<0.05*
6mm inferior	243.00±62.43	242.50±59.69	>0.05
6mm temporal	271.30±39.96	276.00±47.95	>0.05

It is known that physical activities and exercise raise the body temperature. The relationship between exercise and CT was investigated previously and it was reported that exercise had no significant effect on CT [25]. CT varies with a number of factors including age, AL and refractive error [26,27]. Moreover, it was found that refractive error is a major factor in terms of influencing the CT in humans, where the choroid is thin in myopic eyes and thick in non-myopic eyes [4,5]. The finding that external heat produced a substantial effect on CT in one subject suggest that extending the work to a larger group of subjects would be worthwhile. It may also be worth considering changing the experimental paradigm, possibly by extending the length of time the compress was applied to the eye. Some care would be required as the application of ~50ºC to the eye for a prolonged period might be contraindicated for safety issues.

Conclusion

In summary, this study shows no significant group effect of external heat upon CT, except for the outer nasal region. Currently, it is not clear whether applying heat on the human eye has an influence on CT since our study is the first to investigate this relationship. The effect of heat was considerable in one subject suggesting that further investigation is recommended for future studies.

Acknowledgement

None.

Conflict of Interest

None.

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