

Association between Axial Length of the Eye and Length of Each Part of the Body

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Research note

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Abstract

Objective: The purpose of this study is to analyze axial length, body height, hand length, and foot length to find new factors that predict myopia and to identify gender differences as one of the factors of high myopia. A cross-sectional study was conducted as a single observation. Body height, hand length, and foot length were measured according to standard anthropometric methods. Axial length, retinal thickness, and choroidal thickness were measured using the IOL Master 700 and the Heidelberg Spectralis-OCT. To account for body height differences among participants, foot length / body height and hand length / body height were analyzed using a mixed-effects model.

Results: A total of 80 eyes (men, n=20, 40 eyes; women, n=20, 40 eyes) were analyzed. The mean age was 33.5 years (range 21-59 years, SD: 9.6). For choroidal thickness, there was a significant association with axial length in men ($p < 0.001$) and a trend toward an association in women ($p = 0.072$). There was also a significant association between foot length / body height and axial length in men ($p = 0.015$), but not in women ($p = 0.58$). These results suggest that factors that determine body height and foot length may be related to axial length, although they vary by gender.

Introduction

Myopia has been gradually increasing since around 1950 [1], and it is estimated that half of the world's population will be myopic by 2050 [2]. One of the characteristics of myopia is a long axial length (AL). It is generally known that longer AL results in thinner retina and choroid [3–5], and while some reports suggest that AL correlates with body height (BH) [6, 7], others suggest that AL does not correlate with BH [8].

It has been reported that foot length (FL) and hand length (HL) correlate with BH [9]. In Japanese girls, the growth of FL is faster than that of BH until the age of 16, after which the growth of FL is slower than that of BH. Also, after the age of 13, the growth of HL is slower than the growth of BH. In Japanese boys, BH growth shows a similar growth pattern to that of FL and HL growth [10]. Thus, in boys and girls, the growth of FL and HL is known to be different from the growth of BH. Growth hormone (GH) is known to primarily promote longitudinal growth in children and adolescents, but has a variety of important metabolic functions throughout adulthood [11].

Since being female is a risk factor for high myopia [12, 13], we believe it would be valuable to know the gender differences. If new parameters related to AL and other body lengths are discovered, it may shed light on why there are gender differences in severe myopia. To the best of our knowledge, it is not well known whether AL is related to FL or HL. In this study, we will measure each body length including BH, HL, and FL to determine their association with AL and gender differences as a single observation.

Methods

A cross-sectional study was conducted between February 2020 and September 2020 at the Department of Ophthalmology, Keio University Hospital, Tokyo, Japan. All procedures were in accordance with the tenets of the Declaration of Helsinki. Written informed consent was obtained from all subjects prior to the study. This study was approved by the Ethics Committee of Keio University School of Medicine (Approval No. 20190241/UMIN000038975).

Subjects were healthy adults aged 20 years or older who offered to cooperate in this study. Exclusion criteria were as follows: those who could not give their consent to the study, those who had undergone eye surgery such as laser in-situ keratomileusis, those who were currently suffering from eye diseases such as uveitis, those who felt psychological distress when measuring physical parameters, and those who had a strong valgus toe.

Eighty eyes (men, n = 20, 40 eyes; women, n = 20, 40 eyes) were included in the study. Spectral-domain OCT (SPECTRALIS OCT; Heidelberg Engineering, Heidelberg, Germany) with EDI-OCT was used to measure foveal retinal thickness (RT) and subfoveal choroidal thickness (CT). AL was also measured using swept-source optical biometry (IOL Master 700; Carl Zeiss Meditec AG, Jena, Germany).

RT was defined as the distance from the inner limiting membrane to the inferior epithelial edge of the retinal pigment epithelium (RPE). CT was defined as the distance from the outer edge of the hyperreflective line corresponding to the RPE-Bruch's membrane complex to the inner edge of the choroid below the fovea. BH, FL and HL were measured according to standard anthropometric procedures [14, 15]. FL was defined as the linear distance from the most prominent part of the heel to the most distal part of the toe [16]. AL was measured automatically by detecting signals reflected from the cornea and RPE [17].

Descriptive data are presented as mean +/- standard deviation (SD). FL and HL were analyzed as the relative value of FL to BH (FL / BH) and HL to BH (HL / BH), taking into account the difference in BH of the subjects. Statistical analysis was performed to determine the relationship between FL/BH, HL/BH, RT, CT and AL. Left and right eyes were considered as repeated measures, and statistics were performed using a mixed-effects model. Since the aim was to know the gender differences in factors affecting AL, we constructed a model that included the main effect of gender and the interaction of CT, RT, FL/BH, and HL/BH for each gender.

We chose "unstructured" for the repeated measures covariance in order to remove the intentional factor of whether or not a correlation was entered. The dependent variable was AL, factors were left and right, gender, and covariate data were CT, RT, FL/BH, and HL/BH. Fixed effects were gender only, gender x CT, gender x RT, gender x FL / BH, and gender x HL / BH, and their interactions were checked.

Statistical analysis was performed using SPSS (IBM® SPSS® Statistics, version 24). p-value < 0.05 was considered statistically significant.

Results

Forty subjects, 80 eyes, met the inclusion criteria. The mean age was 33.5 years (range: 21–59 years, SD: 9.6).

The differences in each parameter between men and women are shown in Table 1. AL, RT, HL, FL, and FL/BH were significantly different between men and women.

The relationship between CT and AL by gender is shown in Fig. 1, and the relationship between FL/BH and AL by gender is shown in Fig. 2.

There was no significant association between AL and HL/BH in both men ($p = 0.451$) and women ($p = 0.299$). There was no significant association between AL and RT in both men ($p = 0.555$) and women ($p = 0.447$). There was no significant association between AL and age in both men ($p = 0.617$) and women ($p = 0.611$).

Table 1
Clinical profile of the 40 participants.

	Men (n = 40 (R + L))	Women (n = 40 (R + L))	P value
AL (mm)	25.77 ± 1.39 (range, 23.77–28.47)	25.16 ± 1.28 (range, 23.03–28.17)	0.044*
RT (µm)	228.35 ± 15.44 (range, 199–259)	215.30 ± 16.78 (range, 159–252)	0.001*
CT (µm)	309.28 ± 137.28 (range, 106–639)	276.20 ± 87.22 (range, 123–491)	0.202
HL (cm)	18.31 ± 0.81 (range, 17.0–19.7)	16.84 ± 0.88 (range, 15.7–19.2)	< 0.001*
HL / BH	0.11 ± 0.01 (range, 0.09–0.12)	0.11 ± 0.01 (range, 0.09–0.12)	0.583
FL (cm)	25.6 ± 1.09 (range, 23.8–27.3)	22.9 ± 0.89 (range, 21.6–24.8)	< 0.001*
FL / BH	0.15 ± 0.00 (range, 0.14–0.15)	0.14 ± 0.00 (range, 0.14–0.15)	< 0.001*

Discussions

In mixed gender reports, CT has been associated with AL [4, 5]. In the present study, CT was not significantly associated with AL in women. The number of participants was small and the variability may have been large. However, some have reported the gender difference [18, 19]. Similarly, there may be differences in hormone levels between men and women. It is possible that taller participants may secrete more GH and have longer AL. We first focused on the possible influence of GH on AL.

It has been reported that the peak mean refractive values of patients with GH deficiency tend to be hyperopic, while the peak mean refractive values of control healthy children tend to be myopic [20].

de Graaf et al. reported that in children with severe growth retardation due to chronic renal failure, GH therapy maintained equal growth in height and all body segments, with no signs of disproportionate growth in mixed-gender data [21]. On the other hand, Bannink et al. reported that girls with Turner syndrome were treated with GH therapy and grew proportionally except for FL [22].

In our study, there was a significant positive correlation between FL/BH and AL only in men. It has been speculated that GH does not necessarily cause each part to grow in equal proportions and that there may be sex differences [10]. Recently, AL in a group of acromegaly patients did not show any significant difference from the control group [23]. Therefore, it is necessary to consider not only GH, but also other factors.

In the chick model of myopia, it has been estimated that chondrocyte proliferation and expression of growth factors such as TGF- β are higher in the posterior sclera than in control eyes [24]. In a chick model, a correlation between AL and TGF- β has been found [24]. In humans, the amount of TGF- β 2 in the aqueous humor is significantly correlated with AL [25]. It has also been reported that TGF- β is increased by GH [26].

Thus, TGF β is expected to be a growth factor for AL. Female growth factors belonging to the TGF β superfamily are also expressed developmentally in ovarian somatic cells and oocytes, and have been found to function as intrafollicular regulators of folliculogenesis [27].

Therefore, we hypothesized that when ovarian function is overactive, TGF- β may increase and AL may elongate regardless of the degree of GH secretion. From this study, we may be able to obtain an association between FL/BH and AL in men, but it may be difficult in women because of other factors such as increased ovarian function. Even if BH is short, the cause of AL elongation may be due to TGF- β and other factors.

One of the strengths of our study is that we found that the association between FL/BH and AL is appropriate for men. This is the first report of its kind, to our knowledge.

In conclusion, there was a significant association between FL/BH and AL in men, suggesting that factors determining each body size may be different in men and women, although the possibility remains that factors determining BH, FL, and HL are related to AL.

Limitations

- Only adults aged 20 years and older, only Asian data were included.
- Only the association between AL and each body part at some points were analyzed.
- No aqueous humor tests, blood tests, or genetic tests were performed.
- No long-term follow-up and small number of participants were included.

Abbreviations

AL: axial length, BH: body height, FL: foot length, HL: hand length, RT: retinal thickness, CT: choroidal thickness

Declarations

Ethics approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the Keio University School of Medicine (Approval number 20190241/UMIN 000038975, 23 Dec 2019). Written informed consent was obtained from all subjects before examinations.

Consent for publication

Consent forms were obtained from all participants. All procedures adhered to the tenets of the Declaration of Helsinki.

Availability of data and materials

Not applicable.

Competing Interests

Outside the submitted work, Kazuo Tsubota reports his position as CEO of Tsubota Laboratory, Inc., Tokyo, Japan, a company producing myopia-related devices. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. Other authors (AS, TK, KM, YI, AH, KN, and HT) declare no conflict of interest.

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Author's contributions

AS conceptualized this study. AS, KM, and YI collected participants' data. Formal statistical analysis was performed by AS. AS, KM, AH, HT, and TK analyzed and interpreted the participants' data regarding the results. AS was a major contributor in writing the manuscript. TK, KM, AH, KN, HT, and KT supervised this study. All authors have read and approved the final manuscript.

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Figures

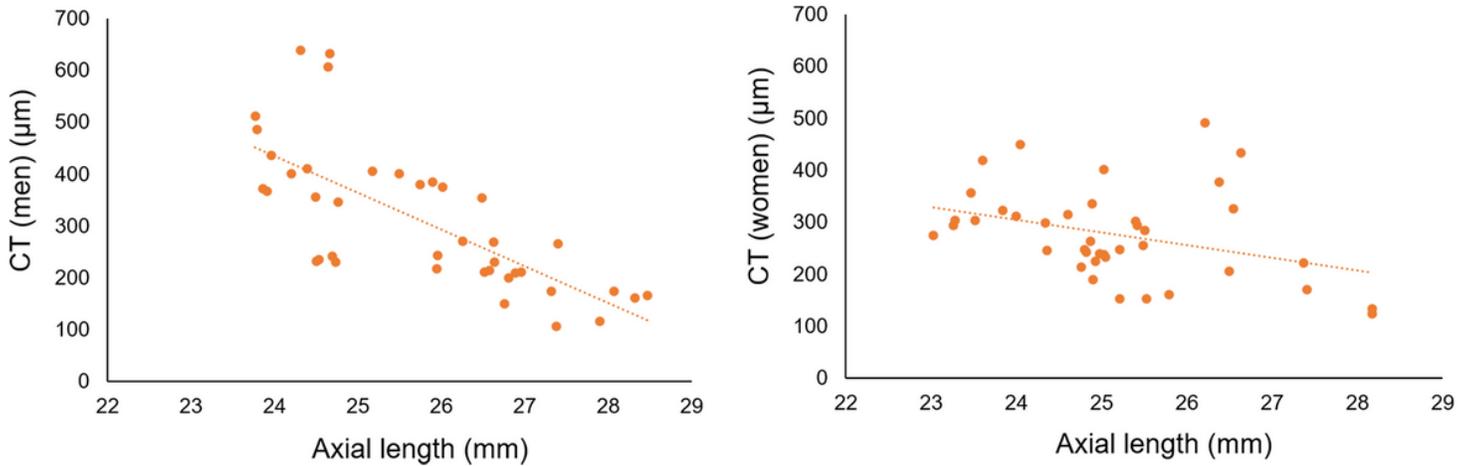


Figure 1

Association between AL and CT in men and women. For CT, there was a significant association with AL in men ($p < 0.001$) and a trend toward association with AL in women ($p = 0.072$).

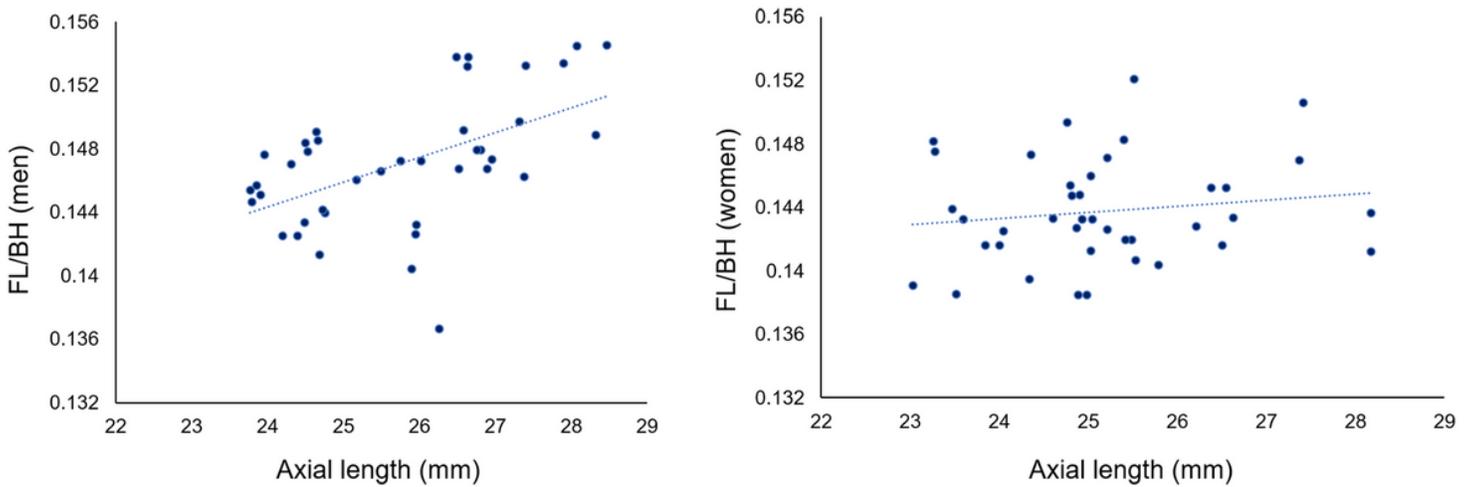


Figure 2

Association between AL and FL / BH in men and women. There was a significant association between FL/BH and AL in men ($p = 0.015$), but no significant association was found in women ($p = 0.58$).