ISSN(print) 1226-5012
J Korean Ophthalmic Opt Soc. 19(3):397-402, September 2014 http://dx.doi.org/10.14479/jkoos.2014.19.3.397

Association between Axial Length and Anthropometric Value in Korean Children

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(Received July 25, 2014: Revised September 6, 2014: Accepted September 18, 2014)

Purpose: To investigate the relationship between axial length (AL) and anthropometric parameters in Korean children. **Methods:** This study included 40 urban school children aged 11-12 years (mean age, 11.95±0.22 years; 45.0% girls) residing in Seoul, South Korea. AL (using partial coherence laser interferometry), corneal radius, refractive error, height (m), and weight (kg) were measured. Body mass index (BMI [kg/m^2]=weight/[height]^2) and degree of obesity (DO[%]=[actual weight standard weight]/standard weight) were calculated. Furthermore, the number of hours spent reading, watching television, and using a computer every day was determined using a detailed questionnaire. **Results:** The students had a mean spherical equivalent refraction of 1.06±0.84 D. Weight (r=0.427, p=0.006), BMI (r=0.508, p=0.001), and DO (r=0.371, p=0.018) showed a significant positive correlation with AL. Furthermore, longer AL was significantly associated with heavier weight (p=0.041), and higher BMI (p=0.015), and higher DO quartiles (p=0.042). After adjust for age, sex, and near-work activities, multivariate linear regression models showed that weight, BMI, and DO were still significantly associated with AL. Among the near-work activities, daily reading time was significantly associated with AL. **Conclusions:** AL was positively related to weight as well as daily reading time in Korean urban school children.

Key words: Axial length, Myopia, Weight, Body mass index, Near-work activities

INTRODUCTION

Myopia affects approximately one-sixth of the world's population[1] and 70% or more of young adolescents.[2] It is alarmingly common in selected regions of Asia, where the prevalence is as high as 80%.[3-5] In a recent Korean study, the mean prevalence of myopia in adolescents aged 12-18 years was 78.8±1.3% (77.9±1.7% in boys and 79.9±1.7% in girls).[6] This value is very high when compared with the prevalence among 5 to 17 year olds in the United States (9.5%) and 4 to 12 year olds in Australia (6.5%).[7,8] Importantly, myopia progresses faster in children who present with the condition at a younger age,[9,10] and early onset of myopia is associated with high myopia in adulthood.[11-13]

Myopia results from the eye having excessive refractive power for its axial length (AL).[14] As AL (the distance from the anterior corneal surface to the retina measured along the visual axis) increases, a myopic shift in refractive error results. The prevalence of myopia is also affected by several environmental factors such as near-work activity, educational level, and outdoor activity.[15-18] Furthermore, Saw *et al*.[19] reported that eyeball length or myopia may be influenced by height or body mass index (BMI). However, few studies have been conducted in children no studies have been in Korean children.

Therefore, the purpose of this study was to assess the relationships of AL with anthropometric parameters after adjusting for near-work activities in Korean elementary school children.

SUBJECTS AND METHODS

1. Participants

This study included 40 volunteer urban school children

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aged 11-12 years (mean age, 11.95±0.22 years; 45.0% girls) in Seoul, South Korea. Students with ocular pathology, strabismus, previous intraocular surgery or laser treatment, and retinal complications were excluded.

2. Measurements

AL was measured using partial coherence laser interferometry (IOLMaster 500; Carl Zeiss Meditec AG, Jena, Germany). The radius of the corneal curvature in the horizontal and vertical meridians and refractive error (spherical equivalent; calculated as a sphere plus half negative cylinder) were estimated with an open-filed autorefractor (SRW-5000, Shin-Nippon, Japan). All measurements were obtained at least five times, and the mean value was chosen. The refractive error was determined as the spherical equivalent (SE) and calculated as the sphere plus half negative cylinder.

Height (m) and weight (kg; by using a digital scale) were measured without shoes and excess clothing. Furthermore, body mass index (BMI [kg/m^2]=weight/[height]^2) and degree of obesity (DO [%]=[actual weight standard weight]/standard weight) were calculated. The standard weight was determined based on Korean child growth standards. The calculated DO was classified into five groups: extremely thin (<20%), thin (≥20% but <10%), average (≥10% but <10%), overweight (≥10% but <20%), and obesity (≥ 20%).[20,21]

A detailed questionnaire was used to determine the amount of time spent on near-work activities. The activities listed were: “reading books; watching television (TV), and using a computer”. The number of hours spent per day performing each activity was recorded.[22]

3. Statistical Analysis

All statistical analyses were performed by using SPSS version 18 for Windows (IBM, Inc., Armonk, NY, USA). As the ALs of the right (24.12±1.02 mm) and left (24.15±1.00 mm) eyes were not significantly different (p=1.000, Mann-Whitney test), only the right eyes were analyzed. The Mann Whitney test was also used to compare the data between boys and girls. The Kruskal-Wallis test was performed to analyze the variations in AL according to quartiles of the anthropometric parameters. The spearman correlation analysis was used to evaluate the correlations between AL and the anthropometric parameters. Multivariate linear regression analysis was performed to determine the associations of AL with the anthropometric parameters and near-work activities. The results are expressed as the mean±standard deviation (SD) of five repeated measurements. P <0.05 was considered significantly different.

RESULTS

Table 1 shows the general characteristics of the volunteers. In the students, who were aged 11 to 12 years, the mean height, weight, BMI, and DO were 1.49±0.07 m, 41.79±7.68 kg, 18.63±2.42 kg/m^2, and 6.02±16.83%, respectively (Table 1). On an average, the students spent 0.79±0.73, 1.75±1.26, and 1.29±1.00 daily reading, watching television, and using a computer, respectively, each day. The mean spherical equivalent refraction was 1.06±0.84 D and the mean corneal radius was 7.77±0.25 D.

The mean AL for all of the students in the study was 24.12±1.02 mm (Table 2); no significant difference (p =

Table 1. Characteristics of the participants

Parameters	Mean± SD or n (%)
Age (yrs)	11.95± 0.22
Sex, boys/girls	22/18 (55.0/45.0)
Stature	
Height (m)	1.49± 0.07
Weight (kg)	41.79± 7.68
BMI (kg/m^2)	18.63± 2.42
DO (%)	−6.02± 16.83
Near working	
Reading hours per day (h)	0.79± 0.73
Watching TV hours per day (h)	1.75± 1.26
Doing computer hours per day (h)	1.29± 1.00
Spherical equivalent (D)	−1.06± 0.84
Corneal radius (mm)	7.77± 0.25

SD, standard deviation; BMI, body mass index; DO, degree of obesity.

Table 2. Mean AL by sex

Total AL (mm)	Sex	AL (mm)	p-value
Mean± SD		Mean± SD	
24.12± 1.02	Boys	24.21± 1.07	0.559
	Girls	24.02± 0.98	

The values represent the mean ± standard deviation.
AL, axial length.
p-value by the Mann-Whitney test.

Table 3. Correlation between AL and anthropometric measurements

Parameters	AL (mm)	
	Correlation coefficient	p-value
Height (m)	0.095	0.561
Weight (kg)	0.427	0.006
BMI (kg/m^2)	0.508	0.001
DO (%)	0.371	0.018

AL, axial length; BMI, body mass index; DO, degree of obesity.
p-value by the Spearman correlation analysis.

Table 4. Differences in AL by quartiles of the anthropometric measurements

Stature	AL (mm)	p-value
	Mean ± SD (Range)	
Height (m)		
1st Quartile	23.91 ± 1.09 (22.39-25.66)	0.441
2nd Quartile	23.81 ± 1.05 (22.01-25.63)	
3rd Quartile	24.48 ± 0.94 (23.21-25.98)	
4th Quartile	24.29 ± 1.01 (22.99-25.82)	
Weight (kg)		
1st Quartile	23.64 ± 0.75 (22.39-24.45)	0.041
2nd Quartile	23.90 ± 1.27 (23.01-25.98)	
3rd Quartile	24.07 ± 0.91 (23.05-25.66)	
4th Quartile	24.88 ± 0.75 (23.50-25.82)	
BMI (kg/m^2)		
1st Quartile	23.40 ± 0.74 (22.39-24.45)	0.015
2nd Quartile	24.05 ± 0.76 (23.05-25.36)	
3rd Quartile	24.15 ± 1.14 (23.01-25.98)	
4th Quartile	24.89 ± 0.92 (23.06-25.82)	
DO (%)		
1	23.54 ± 0.74 (22.39-24.45)	0.042
2	23.83 ± 1.27 (22.01-25.36)	
3	24.15 ± 0.93 (23.05-25.98)	
4	24.93 ± 0.90 (23.50-25.82)	
5	25.21 ± 0.53 (24.88-25.82)	

The values represent the mean ± standard deviation (range).
AL, axial length; BMI, body mass index; DO, degree of obesity.
p-value by the Kruskal-wallis test.

0.559) in AL was noted between boys (24.21±1.07 mm) and girls (24.02±0.98 mm). Furthermore, height was not significantly correlated with AL (r=0.095, p=0.561). However, AL was significantly correlated with weight (r=0.427, p= 0.006), BMI (r=0.508, p=0.001), and DO (r=0.371, p= 0.018) (Table 3).

Table 4 shows the mean AL according to quartiles of height, weight, and BMI. A significant difference in AL among the height quartiles (p=0.441) was not found. In contrast, the heavier weight (p=0.041) and higher BMI (p =0.015) quartiles and the groups with a higher DO groups (p=0.042) were significantly associated with longer AL.

Multivariate linear regression models revealed similar results (Table 5); after adjustment for age, sex, and near-work activities, AL was still significantly associated with weight, BMI, and DO. Among the near-work activities, daily reading time was significantly associated with AL.

DISCUSSION

Myopia has become a public health issue worldwide in the past few years.[23-25] Atchison *et al.*[26] measured ocular dimensions in myopic and emmetropic eyes by ultrasonography and found that highly myopic eyes were longer: eyes with refractive errors of +0.75 to 0.50 and 6.61 to 12 D had mean lengths of 23.3±0.7 and 26.4±0.6 mm, respectively. These results suggest that AL is an important determinant of the ocular refractive state. It increases early in life, concomitant with the overall growth and development in childhood.[27-29] However, few studies have addressed the relationships between ocular dimensions and anthropometric parameters in children. Moreover, despite the very high prevalence of myopia in South Korea, the association of AL with anthropometric parameters in Korean children has not been investigated. In this study, the relationships between AL and height, weight, BMI, DO, and near-work activities were examined in Korean school children aged 11-12 years. The results showed that after adjustment for near-work activity, heavier students were significantly associated with the longer AL.

Previous studies have suggested a possible relationship between adult stature and refraction because taller and heavier individuals tend to be more myopic than shorter and lighter persons.[30,31] Wong *et al.*[32] also reported that taller Chinese adults tend to have longer ALs, after adjusting for education and socioeconomic indicators. However, other studies, including a large population-based survey, have not shown any relationship between adult stature and refraction.[32-35] Although these inconsistencies may be attributed to methodological variations among the previous stud-

Table 5. Multivariate linear regression models of AL and the anthropometric measurements

Parameters	AL (mm)					
	Model with weight		Model with BMI		Model with DO	
	Regression coefficients	p-value	Regression coefficients	p-value	Regression coefficients	p-value
Age	0.116	0.473	0.125	0.440	0.040	0.799
Sex	0.074	0.618	0.073	0.619	0.165	0.265
Height	–0.471	0.051	–0.122	0.452	–0.472	0.051
Somatotype variable	0.702[a]	0.004	0.501[b]	0.003	0.300[c]	0.004
Reading	0.301	0.048	0.303	0.046	0.692	0.049
TV	0.139	0.373	0.138	0.373	0.144	0.357
Computer	0.197	0.229	0.205	0.208	0.189	0.247

In models 1, 2, and 3, the p-values were 0.013, 0.006, and 0.017, respectively.
[a]weight, [b]body mass index (BMI), and [c]degree of obesity (DO).
p-value by the multivariate linear regression analysis.

ies,[30-35] height may have no bearing on the ocular refractive state. In the present study, weight, BMI, and DO were independently correlated with AL, and heavier students tended to have longer ALs, but height showed no such relationship. Even after adjust for age, sex, and near-work activities, no association of height and AL was found.

Near-work activity is reportedly an important risk factor for myopia in young children.[18,36-41] In this study, daily reading time was strongly related to AL. Myopia is a complex eye condition; therefore, any association of refraction and ocular biometry and stature is likely to be complex[42] and attributable to both genetic and environmental factors such as social status, educational level, and occupation.[43-47] Although taller individuals are likely to come from higher socioeconomic status and have better nutrition, higher educational levels, and occupations associated with a greater amount of near-work activities,[32] there was no relationship between height and AL in our results.

The limitation of this study could not include the genetic and socioeconomic factors associated with anthropometric value and myopia. Although this study analyzed a small sample, various anthropometric parameters including DO were assessed. Furthermore, given that children are reaching adolescence earlier in Korea,[21] the present findings are important for protection against myopia.

CONCLUSION

In conclusion, heavier Korean children tend to have longer ALs. Furthermore, daily reading time is strongly associated with AL. This results could be used as the basis for the development of school health programs. Long term follow-up analyses will be needed to clarify the relative roles of anthropometric factors in AL.

ACKNOWLEDGEMENTS

This study was supported by the Research Program funded by the Baekseok University (2014).

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한국 어린이의 안축장과 신체 계측치와의 관련성

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투고일(2014년 07월 25일), 수정일(2014년 09월 6일), 게재확정일(2014년 9월 18일)

목적: 본 연구는 한국 어린이를 대상으로 안축장과 신체 계측치와의 관련성을 조사하였다. **방법:** 서울지역에서 11-12세(평균 연령: 11.95±0.22세, 여학생: 45.0%)의 초등학생 40명을 대상으로 하였다. 부분 간섭측정법에 의한 안축장, 각막 곡률반경, 굴절이상도, 신장(m), 그리고 체중(kg)을 측정하였고, 체질량지수(BMI [kg/m^2]=weight/[height]^2)와 비만정도지수(DO[%]=[actual weightstandard weight]/standard weight)는 계산하였다. 근업 활동으로 1일 평균 독서시간, TV 시청시간, 그리고 컴퓨터 사용시간에 대하여 설문하였다. **결과:** 전체 대상자의 평균 굴절이상도는 1.06±0.84 D였고, 이들의 안축장과 몸무게(r=0.427, p=0.006), 체질량지수(r=0.508, p=0.001), 비만정도지수(r=0.371, p=0.018)는 유의한 양의 상관관계를 보였다. 또한 안축장은 체중(p=0.041)과 체질량지수(p=0.015)의 1사분위수, 그리고 비만정도지수가 가장 높은 그룹(p=0.042)에서 유의하게 길었다. 연령, 성별, 그리고 근업 활동을 보정한 후에 다중회귀분석에서 체중, 체질량지수 그리고 비만정도지수는 안축장과 유의한 관련성을 보였고, 특히, 근업 활동에서 1일 독서시간은 안축장과 유의한 관련성을 보였다. **결론:** 한국 초등학생의 안축장은 체중과 관련이 있었다. 특히, 긴 안축장과 1일 독서시간은 유의한 관계를 보였다.

주제어: 안축장, 근시, 체중, 체질량지수, 근업 활동