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RELATIONSHIP BETWEEN LIFESTYLE AND THE PROGRESSION OF AXIAL AND SEGMENTAL OCULAR BIOMETRIC LENGTHS IN TEENAGERS – A PORTUGUESE COHORT FROM THE OPORTO MYOPIA STUDY

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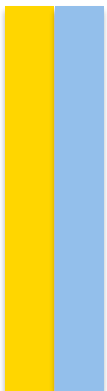

RELATIONSHIP BETWEEN LIFESTYLE AND THE PROGRESSION OF AXIAL AND SEGMENTAL OCULAR BIOMETRIC LENGTHS IN TEENAGERS – A PORTUGUESE COHORT FROM THE OPORTO MYOPIA STUDY

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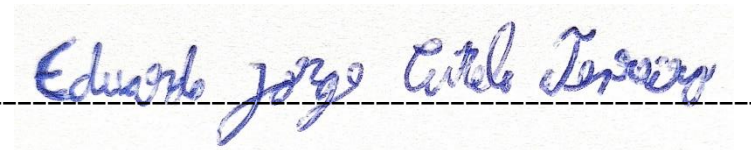
Junho 2024

Declaração de Integridade



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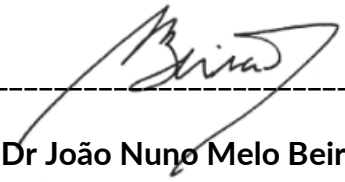
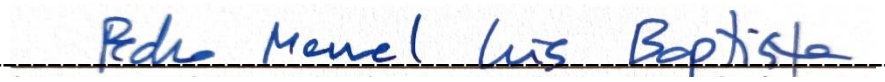


Professor Dr João Nuno Melo Beirão (Orientador)



Dr Pedro M. L. Baptista (Coorientador)

RESUMO

Objetivo:

Este estudo foi realizado com o objetivo de perceber que fatores do estilo de vida podem estar associados ao aumento de miopia, numa coorte de adolescentes portugueses. Pretende-se realizar este estudo através de medições biométricas axiais e segmentares oculares e a sua progressão ao longo do estudo.

Estudo realizado no Centro Hospitalar e Universitário do Porto, Porto, Portugal.

Métodos:

Este estudo de coorte prospetivo teve a contribuição de um total de 63 participantes com um número total de 126 olhos, tendo os seus dados biométricos oculares medidos em 2 momentos distintos, com 2.2 (+-0,3) anos de intervalo. Os dados biométricos oculares (comprimento axial (AL) e comprimentos biométricos oculares segmentares (Espessura Central Corneana(CCT), Profundidade da Camara Anterior (ACD) e Espessura da Lente (LT) foram medidas nos dois momentos por meio de OCT de fonte varrida IOL MASTER 700 (ZEISS, Alemanha). Depois a variável Comprimento de Cavidade Vítrea (VCT) foi criada [VCL=AL – (CCT + ACD + LT)]. No segundo momento, no fim do período de seguimento, foi realizado um questionário que incluía questões relativas a história familiar de miopia, alergias, posição de sono, sintomas da superfície ocular, hábito de esfregar os olhos, exposição solar, hábitos de leitura e hábitos de utilização de dispositivos digitais. Posteriormente, o rácio entre VCL e AL(R_VCL/AL) foi calculado e os deltas de progressão foram criados para AL (Δ_AL), VCL (Δ_VCL) e R_VCL/AL (Δ_R_VCL/AL). Análise nos diferentes subgrupos foi realizada para evidenciar as diferenças individuais (presença de história familiar de miopia, história de alergias, e predomínio de posição de sono ventral) e entre olhos (com posição de sono ipsilateral, com sintomas de superfície ocular, e os que estavam sujeitos a hábitos de esfregar os olhos. Foram efetuadas correlações (coeficiente de posto de Spearman e de Pearson) entre os parâmetros biométricos e as variáveis de estilo de vida de horas semanais de atividades de exterior, horas semanais de atividade física, horas diárias a utilizar dispositivos digitais e horas diárias a ler/escrever.

Resultados:

Um total de 126 olhos de 63 indivíduos com uma idade média inicial de 14.2(+-2.6) anos de idade foram analisados. No seguimento, indivíduos com história de alergias tinham VCL mais pequeno (16.425 VS 16.812, p0.08), R_VCL/AL mais baixo ao seguimento (0.695 VS 0.701, p0.03) e menos Δ_AL (0.087 VS 0.15 mm, p0.032). Olhos com sujeitos a hábitos de esfregar tinham um R_VCL/AL mais alto ao seguimento (0.700 VS 0.695, p0.08). Houve correlação entre as horas semanais de atividade exterior com um VCL aumentado ao seguimento(Pearson 0.175, p 0.05) e entre horas passadas diariamente em dispositivos digitais e Δ_R_VCL/AL (Pearson 0.177, p 0.048).

Conclusão

Este estudo destaca a importância do estilo de vida e hábitos, nomeadamente aqueles relacionados com a superfície ocular, atividades exteriores e dispositivos digitais, na biometria do olho e nas suas mudanças ao longo do tempo, em indivíduos jovens e adolescentes. Destaca também o conceito de analisar o comprimento axial do olho jovem como a suma de segmentos. Estes dados são importantes para criar estratégias eficazes de prevenção da epidemia global da miopia nas décadas vindouras.

ABSTRACT

Purpose:

This study aims to study factors that lead to an increase in myopia in a cohort of Portuguese teenagers. The aim is to study it by describing axial and segmental ocular biometric lengths in a cohort of portuguese teenagers and its progression along the follow-up. Lastly, it aims to correlate lifestyle data with axial and segmental ocular biometric lengths at the end of follow up and with its progression from the baseline.

Setting:

Centro Hospitalar e Universitário do Porto, Porto, Portugal

Methods:

A total of 63 participants, with a combined total number of 126 eyes contributed to this prospective cohort study, having their ocular biometric data measured in 2 timepoints, 2.2 (+-0.3) years apart. This ocular biometric data (Axial length (AL) and segmental ocular biometric lengths (Central Corneal Thickness (CCT), Anterior Chamber Depth (ACD) and Lens Thickness (LT)) was assessed in both timepoints by means of swept source OCT with the IOL MASTER 700 (ZEISS, Germany). Then, the variable Vitreous Cavity Length was built [VCL=AL – (CCT + ACD + LT)]. In the second timepoint, at the end of the follow-up, participants answered a questionnaire including questions regarding familiar history of myopia, allergies, sleeping position, ocular surface symptoms, eye scratching habits, sun exposure, digital devices utilization and reading habits. Then , the ration between VCL and AL (R_VCL/AL) was calculated and deltas of progression were built for AL (Δ_AL), VCL (Δ_VCL) and R_VCL/AL (Δ_R_VCL/AL).Different subgroups analysis was made to address differences in individuals (those with family history of myopia, those with allergic diseases and those with predominantly ventral sleeping position) and difference in eyes (those with ipsilateral sleeping position, those with ocular surface symptoms and those submitted to scratching habits). Correlations (Spearman's rank and Pearson coefficients) were addressed between biometric parameters and the individual lifestyle variables of weekly hours of outdoor activity, weekly hours of physical activity, daily hours spent on digital devices and daily hours spent reading/writing.

Results:

A total of 126 eyes from 63 individuals with a mean age at baseline of 14.2(+-2.6) years old were analyzed. At follow-up, the individuals with allergies history had eyes with a smaller VCL (16.425 VS 16.812, p0.08), lower R_VCL/AL at follow up (0.695 VS 0.701, p0.03) and less Δ_AL (0.087 VS 0.15 mm, p0.032). Eyes with reported eye scratching habits had higher R_VCL/AL at follow up (0.700 VS 0.695, p0.08). There was a correlation between weekly hours of outdoor activity with an increased VCL at follow up (Pearson 0.175, p 0.05) and between daily hours spent on digital devices and Δ_R_VCL/AL (Pearson 0.177, p 0.048).

Conclusions:

The present study highlights the importance of lifestyle history and habits, namely those related with ocular surface, outdoor activity and digital devices, in the biometric status of the eye and its change over time, in young individuals during adolescence. Furthermore, it highlights the concept of analyzing the axial growth of the young eye from a sum of segments perspective. These data are important to help design effective strategies for the prevention of the global myopia epidemic in the upcoming decades.

Financial Disclosure of all Authors

The authors have no relevant financial or non-financial interests to disclose.

Key words

Myopia; Emetropization; Eye scratch; Outdoor activities; Digital work; Children; Axial Length growth; Sum of Segments

LIST OF ABBREVIATONS

AL - Axial length

ACD.-. Anterior Chamber Depth

CCT --Central Corneal Thickness

LT- Lens Thickness

VCL - Vitreous Cavity Length

R_VCL/AL – Ratio VCL/AL

Δ_AL – Delta AL

Δ_VCLL – Delta VCL

Δ_R_VCL/AL – Delta Ratio VCL/AL

TABLES

Table I. Demographic and lifestyle (all sample: 63 individuals / 126 eyes)

	Mean	SD
Age at baseline (years)	14,1	2,6
Age at the end of follow-up (years)	16,5	2,6
Follow up (years)	2,4	0,3
Weekly hours of outdoor activity (hours)	3,4	1,9
Weekly hours of physical activity (hours)	2,1	1,9
Daily hours spent on digital devices (hours)	3,3	1,5
Daily hours spent reading/writing (hours)	1,8	1,4
	Frequency (individuals)	**% (individuals)**
Gender		
Male	27	42,9
Female	36	57,1
Family history of myopia		
No	39	61,9
Yes	24	38,1
Alergies		
No	35	55,6
Yes	28	42,9
Ventral sleeping		
No	25	39,7
Yes	38	60,3
	Frequency (eyes)	**% (eyes)**
Ipsilateral sleeping position		
No	74	58,7
Yes	52	41,3
ocular surface symptoms		
No	69	54,0
Yes	57	44,4
Eye Scratching habits		
No	42	33,3
Yes	84	66,7

Table II. Ocular biometry (all sample: 63 individuals / 126 eyes)

	Median	Mean	Upper	Lower	SD
Baseline					
Baseline AL	23,576	23,701	23,919	23,484	1,233
Baseline CCT	0,536	0,534	0,540	0,528	0,036
Baseline ACD	3,657	3,645	3,685	3,606	0,223
Baseline AQD	3,130	3,111	3,151	3,072	0,225
Baseline LT	3,480	3,498	3,529	3,466	0,178
Vitreous Cavity BASELINE	16,383	16,572	16,783	16,361	1,193
Ratio Vitreous Cavity / AL BASELINE	0,697	0,698	0,701	0,695	0,015
Follow Up					
Follow up AL	23,629	23,824	24,053	23,594	1,302
Follow up CCT	0,548	0,543	0,550	0,537	0,037
Follow up ACD	3,675	3,633	3,673	3,592	0,230
Follow up AQD	3,116	3,089	3,130	3,049	0,231
Follow up LT	3,508	3,542	3,575	3,508	0,192
Vitreous Cavity FOLLOW UP	16,416	16,649	16,872	16,427	1,260
Ratio Vitreous Cavity / AL FOLLOW UP	0,697	0,698	0,701	0,695	0,016
Deltas					
DELTA AL	0,092	0,122	0,152	0,092	0,170
DELTA Vitreous Cavity	0,073	0,091	0,121	0,062	0,167
DELTA Ratio Vitreous Cavity / AL	5,736×10-5	1,661×10-4	5,775×10-4	-2,454×10-4	0,002

Footnotes:AL- Axial length; CCT-Central Corneal Thickness; (ACD)- Anterior Chamber Depth; LT- Lens Thickness; VCL- Vitreous Cavity Length (VCL) [VCL=AL – (CCT + ACD + LT)];

Table III. Per-individual analysis (63 individuals)

	Ipsilateral sleeping position					Ocular surface symptoms					Eye Scratching habits				
	Yes (n=52)		No (n=74)		p	Yes (n=57)		No (n=69)		p	Yes (n=84)		No (n=42)		p
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age at baseline (years)	14,236	2,573	13,546	2,674	0,213	14,532	2,502	13,890	2,579	0,176	14,418	2,722	13,449	2,303	0,037
Age at the end of follow-up (years)	16,840	2,668	16,162	2,582	0,229	17,017	2,489	16,261	2,598	0,109	16,841	2,725	15,858	2,366	0,035
Follow up (years)	2,335	0,356	2,406	0,316	0,500	2,485	0,310	2,372	0,320	0,094	2,423	0,312	2,408	0,337	0,965
Baseline															
Baseline AL	23,765	1,351	23,657	1,150	0,694	23,879	1,213	23,584	1,249	0,114	23,826	1,261	23,452	1,148	0,080
Baseline ACD	3,660	0,225	3,635	0,223	0,444	3,663	0,230	3,632	0,221	0,284	3,661	0,205	3,615	0,257	0,297
Baseline AQD	3,131	0,225	3,098	0,226	0,417	3,134	0,224	3,096	0,229	0,360	3,119	0,206	3,095	0,261	0,566
Baseline LT	3,494	0,193	3,501	0,168	0,615	3,489	0,178	3,503	0,181	0,610	3,486	0,187	3,523	0,157	0,214
Baseline CCT	0,529	0,037	0,538	0,034	0,197	0,530	0,038	0,536	0,033	0,314	0,541	0,035	0,520	0,032	0,001
Vitreous Cavity BASELINE	16,611	1,330	16,545	1,094	0,886	16,726	1,152	16,473	1,229	0,146	16,680	1,225	16,352	1,107	0,118
Ratio Vitreous Cavity / AL BASELINE	0,698	0,017	0,698	0,014	0,964	0,700	0,013	0,697	0,017	0,296	0,699	0,015	0,695	0,015	0,182
Ratio CA / AL BASELINE	0,154	0,009	0,154	0,009	0,781	0,153	0,008	0,154	0,010	0,643	0,154	0,008	0,154	0,010	0,800
Follow up															
Follow up AL	23,881	1,416	23,783	1,225	0,668	24,008	1,306	23,701	1,301	0,159	23,950	1,327	23,571	1,229	0,114
Follow up ACD	3,653	0,233	3,619	0,228	0,371	3,661	0,236	3,612	0,226	0,106	3,650	0,209	3,598	0,265	0,276
Follow up AQD	3,114	0,231	3,072	0,230	0,245	3,122	0,226	3,067	0,236	0,091	3,100	0,211	3,069	0,267	0,496
Follow up LT	3,533	0,210	3,548	0,179	0,355	3,522	0,184	3,557	0,200	0,297	3,525	0,196	3,575	0,179	0,109
Follow up CCT	0,539	0,039	0,546	0,036	0,260	0,539	0,040	0,546	0,035	0,341	0,551	0,036	0,528	0,034	0,001
Vitreous Cavity FOLLOW UP	16,696	1,388	16,617	1,171	0,753	16,826	1,234	16,532	1,284	0,156	16,775	1,277	16,398	1,201	0,097
Ratio Vitreous Cavity / AL FOLLOW UP	0,698	0,018	0,698	0,014	0,952	0,700	0,014	0,697	0,017	0,236	0,700	0,016	0,695	0,016	0,080
Ratio CA / AL FOLLOW UP	0,153	0,010	0,152	0,009	0,602	0,153	0,008	0,153	0,010	0,966	0,153	0,009	0,153	0,010	0,947
Deltas															
DELTA AL	0,117	0,168	0,126	0,172	0,753	0,130	0,184	0,118	0,160	0,693	0,124	0,169	0,119	0,173	0,533
DELTA Vitreous Cavity	0,085	0,167	0,096	0,168	0,966	0,099	0,180	0,084	0,159	0,631	0,095	0,168	0,084	0,167	0,657
DELTA Ratio Vitreous Cavity / AL	8,337×10-5	0,002	2,250×10-4	0,002	0,640	2,908×10-4	0,002	-32,660	0,002	0,694	3,104×10-4	0,002	-16,960	0,002	0,807
DELTA Ratio CA / AL	-0,001	0,003	-0,001	0,002	0,355	-93,690	0,002	-0,002	0,003	0,142	-0,001	0,003	-0,001	0,002	0,981

Footnotes: AL- Axial length; CCT-Central Corneal Thickness; (ACD)- Anterior Chamber Depth; LT- Lens Thickness; VCL- Vitreous Cavity Length (VCL) [VCL=AL – (CCT + ACD + LT)].

Table IV. Per-eye analysis (126 eyes)

	Ipsilateral sleeping position					Ocular surface symptoms					Eye Scratching habits				
	Yes (n=52)		No (n=74)		p	Yes (n=57)		No (n=69)		p	Yes (n=84)		No (n=42)		p
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age at baseline (years)	14,236	2,573	13,546	2,674	0,213	14,532	2,502	13,890	2,579	0,176	14,418	2,722	13,449	2,303	0,037
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Baseline ACD	3,660	0,225	3,635	0,223	0,444	3,663	0,230	3,632	0,221	0,284	3,661	0,205	3,615	0,257	0,297
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Baseline LT	3,494	0,193	3,501	0,168	0,615	3,489	0,178	3,503	0,181	0,610	3,486	0,187	3,523	0,157	0,214
Baseline CCT	0,529	0,037	0,538	0,034	0,197	0,530	0,038	0,536	0,033	0,314	0,541	0,035	0,520	0,032	0,001
Vitreous Cavity BASELINE	16,611	1,330	16,545	1,094	0,886	16,726	1,152	16,473	1,229	0,146	16,680	1,225	16,352	1,107	0,118
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Ratio CA / AL BASELINE	0,154	0,009	0,154	0,009	0,781	0,153	0,008	0,154	0,010	0,643	0,154	0,008	0,154	0,010	0,800
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Follow up ACD	3,653	0,233	3,619	0,228	0,371	3,661	0,236	3,612	0,226	0,106	3,650	0,209	3,598	0,265	0,276
Follow up AQD	3,114	0,231	3,072	0,230	0,245	3,122	0,226	3,067	0,236	0,091	3,100	0,211	3,069	0,267	0,496
Follow up LT	3,533	0,210	3,548	0,179	0,355	3,522	0,184	3,557	0,200	0,297	3,525	0,196	3,575	0,179	0,109
Follow up CCT	0,539	0,039	0,546	0,036	0,260	0,539	0,040	0,546	0,035	0,341	0,551	0,036	0,528	0,034	0,001
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Ratio Vitreous Cavity / AL FOLLOW UP	0,698	0,018	0,698	0,014	0,952	0,700	0,014	0,697	0,017	0,236	0,700	0,016	0,695	0,016	0,080
Ratio CA / AL FOLLOW UP	0,153	0,010	0,152	0,009	0,602	0,153	0,008	0,153	0,010	0,966	0,153	0,009	0,153	0,010	0,947
Deltas															
DELTA AL	0,117	0,168	0,126	0,172	0,753	0,130	0,184	0,118	0,160	0,693	0,124	0,169	0,119	0,173	0,533
DELTA Vitreous Cavity	0,085	0,167	0,096	0,168	0,966	0,099	0,180	0,084	0,159	0,631	0,095	0,168	0,084	0,167	0,657
DELTA Ratio Vitreous Cavity / AL	8,337×10-5	0,002	2,250×10-4	0,002	0,640	2,908×10-4	0,002	-32,660	0,002	0,694	3,104×10-4	0,002	-16,960	0,002	0,807
DELTA Ratio CA / AL	-0,001	0,003	-0,001	0,002	0,355	-93,690	0,002	-0,002	0,003	0,142	-0,001	0,003	-0,001	0,002	0,981

Footnotes: AL- Axial length; CCT-Central Corneal Thickness; (ACD)- Anterior Chamber Depth; LT- Lens Thickness; VCL- Vitreous Cavity Length (VCL) [VCL=AL – (CCT + ACD + LT)].

Table V. Correlations analysis (per-individual)

Lifestyle variable	Ocular biometric variables	Pearson		Spearman	
		r	p	rho	p
Weekly hours of outdoor activity	Vitreous Cavity BASELINE	0,179	0,046	0,154	0,086
Weekly hours of outdoor activity	Ratio Vitreous Cavity / AL BASELINE	0,151	0,092	0,139	0,123
Weekly hours of outdoor activity	Vitreous Cavity FOLLOW UP	0,175	0,050	0,167	0,062
Weekly hours of outdoor activity	Ratio Vitreous Cavity / AL FOLLOW UP	0,148	0,097	0,141	0,116
Weekly hours of outdoor activity	DELTA AL	-0,047	0,605	-0,005	0,952
Weekly hours of outdoor activity	DELTA Vitreous Cavity	-0,054	0,551	-0,012	0,897
Weekly hours of outdoor activity	DELTA Ratio Vitreous Cavity / AL	-0,043	0,633	0,038	0,675
Weekly hours of physical activity	Vitreous Cavity BASELINE	0,032	0,727	0,041	0,653
Weekly hours of physical activity	Ratio Vitreous Cavity / AL BASELINE	0,036	0,694	0,062	0,493
Weekly hours of physical activity	Vitreous Cavity FOLLOW UP	0,042	0,639	0,050	0,576
Weekly hours of physical activity	Ratio Vitreous Cavity / AL FOLLOW UP	0,048	0,593	0,092	0,306
Weekly hours of physical activity	DELTA AL	-0,005	0,956	-0,022	0,806
Weekly hours of physical activity	DELTA Vitreous Cavity	3,576×10-4	0,997	8,623×10-4	0,992
Weekly hours of physical activity	DELTA Ratio Vitreous Cavity / AL	0,042	0,644	0,048	0,596
Daily hours spent on digital devices	Vitreous Cavity BASELINE	0,087	0,332	0,042	0,638
Daily hours spent on digital devices	Ratio Vitreous Cavity / AL BASELINE	0,135	0,134	0,117	0,195
Daily hours spent on digital devices	Vitreous Cavity FOLLOW UP	0,090	0,314	0,044	0,621
Daily hours spent on digital devices	Ratio Vitreous Cavity / AL FOLLOW UP	0,153	0,087	0,131	0,144
Daily hours spent on digital devices	DELTA AL	0,051	0,574	0,031	0,732
Daily hours spent on digital devices	DELTA Vitreous Cavity	0,099	0,272	0,077	0,393
Daily hours spent on digital devices	DELTA Ratio Vitreous Cavity / AL	0,177	0,048	0,132	0,142
Daily hours spent reading/writing	Vitreous Cavity BASELINE	-0,111	0,218	-0,121	0,180
Daily hours spent reading/writing	Ratio Vitreous Cavity / AL BASELINE	-0,161	0,072	-0,138	0,125
Daily hours spent reading/writing	Vitreous Cavity FOLLOW UP	-0,089	0,320	-0,104	0,247
Daily hours spent reading/writing	Ratio Vitreous Cavity / AL FOLLOW UP	-0,135	0,131	-0,124	0,168
Daily hours spent reading/writing	DELTA AL	0,052	0,560	0,067	0,458
Daily hours spent reading/writing	DELTA Vitreous Cavity	0,066	0,466	0,062	0,492
Daily hours spent reading/writing	DELTA Ratio Vitreous Cavity / AL	0,113	0,210	0,071	0,429

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INTRODUCTION

Myopia is a common and complex ophthalmological entity and was estimated to affect approximately 2.5 billion people worldwide in 2020[1,2]. As it is increasing, myopia and high myopia are expected to be present, respectively, in about 50% and 10% of the world´s population in 2050[2].

Worldwide patterns and trends for the prevalence of myopia are studied in many population-based studies. The steeper trajectories of myopia prevalence are well known in east and southeast Asia[3]. However, consistent data from the European Eye EpidemiologyConsortium[4] or the United States of America National Health and Nutrition Examination Survey[5] describe the same.

Evidence of increasing myopia prevalence carries clinical and economic implications. The increased requirement for detection and treatment of myopia, entailing glasses, contact lenses, or more recently laser refractive surgery, has significant implications for clinical optometric and ophthalmic service provision, and the health care system[6]. Additional ophthalmic services will be needed for treatable sight-threatening complications, such as retinal detachment, glaucoma[7], and cataract[8]. The increasing prevalence of myopia also implies that untreatable complications, such as myopic maculopathy[1], most commonly seen in high myopia, will become more common.

This will result in more visual impairment in middle- to older-aged individuals, including a proportion of the working-age population, with consequent economic implications. Recent strong modeling data from meta-analysis has estimated a global potential productivity loss associated with the burden of vision impairment at US$244 billionfrom uncorrected myopia and US$6 billionfrom myopic macular degeneration in the year of 2015[9].

For several decades, the ophthalmology community has been studying the possible causes for the increase in the prevalence of this entity, to try to prevent the aforementioned burden.

Although the genetic load is important, the last decades have demonstrated that in economically developed societies, most myopia appears during childhood, particularly during the school years – *the school myopia* – and only a small proportion of myopia is clearly familial, generally early in onset and of high level, with defined chromosomal localizations and in some cases, causal genetic mutations[10].

Myopia increase is concurrent with the rise in myopigenic activities on a background of increasing urbanization of the populations. The factors most associated with myopia progression are the high level of education[4] and low time spent outdoors[11-14], with less stablished evidence regarding physical activity[12,13]and the use of digital devices[15,16], including its rise with COVID pademic[17].

Despite the growing evidence of these associations, the causal relationship still lacks evidence and axial growth is not addressed in most studies. On the other hand, and thinking about axial myopia, especially high myopia, as a disproportionate growth of the posterior segment during eye growth, there is no data on this issue in the literature.

The present study is aimed to describe axial and segmental ocular biometric lengths in a cohort of portuguese teenagers and to correlate its progression along the follow-up with lifestyle data.

MATERIAL AND METHODS

Design

This is a prospective cohort study. Data was collected from 2 timepoints, spaced by 2.2 (+-0.3) years, between 2020 and 2023.The study adhered to the tenets of the Declaration of Helsinki.

Setting

Centro Hospitalar e Universitário do Porto.

Inclusion and exclusion criteria

One-hundred and twenty-six eyes from sixty-three healthy individuals were included, with a mean age of 14.1 years at the beginning of the study and a standard deviation of 2.6 years. The follow-up was done after 2.4 years. There were 27 male and 36 female, 39 individuals with family history of myopia and 24 without, 35 with allergies and 24 without, 25 individuals with ventral sleeping and 38 without. Referring to the eyes as separate entities, there are 74 eyes ipsilateral to the sleeping position and 52 opposite, 69 eyes with reported ocular surface symptoms and 57 without and 42 eyes subject to eye scratching and 84 not subject to it.

Exclusion criteria were: familial or personal ocular pathologic history besides myopia; amblyopia history: ocular surgeries; ocular inflammation at the time of examinations; corneal leucomas or other corneal problems; inability to perform the exams; inability to answer the questionnaire.

Lifestyle data

General health data and lifestyle data from the follow-up interval were collected at the end of follow-up, through a questionnaireaccepted and validated by the Centro Hospitalar e Universitário do Porto Ethical Commission (nr 158-DEFI/160-CE),including questions regarding familiar history of myopia, allergies, sleeping position, ocular surface symptoms, eye scratching habits, sun exposure, digital devices utilization and reading habits. Anonymized data was collected via *Google Form***(attachment 1).** Filling out the form was done by the individual, with the help of parents when necessary.

Ocular Biometric data

Ocular biometric data from Axial length (AL) and segmental ocular biometric lengths (Central Corneal Thickness (CCT), Anterior Chamber Depth (ACD) and Lens Thickness (LT)) were assessed in both timepoints by means of swept source OCT with the IOL MASTER 700 (ZEISS, Germany). The variable Vitreous Cavity Length (VCL) was Built [VCL=AL – (CCT + ACD + LT)]. Then ratios between

VCL and AL (R_VCL/AL) were calculated and deltas of progression were built for AL (Δ_AL), VCL (Δ_VCL) and R_VCL/AL (Δ_R_VCL/AL).

Inter-individual study

Ocular biometric data including the calculated Ratios and Deltas were compared to address differences between individuals with family history of myopia, those with allergic diseases and those with predominantly ventral sleeping position.

Inter-eye study

Ocular biometric data including the calculated Ratios and Deltas were compared to address differences between eyes with ipsilateral sleeping position, those with ocular surface symptoms and those submitted to scratching habits with eyes without these conditions.

Study of correlations

Correlations (Spearman's rank and Pearson coefficients) were addressed between biometric parameters and the individual lifestyle variables of weekly hours of outdoor activity, weekly hours of physical activity, daily hours spent on digital devices and daily hours spent reading/writing.

Statistical Analysis

Descriptive statistics of all dataset were calculated for lifestyle and ocular biometric data.

Normality of the data was tested with the Shapiro-Wilk and Kolmogorov-Smirnov tests.

When parametric analysis could be applied, the Student t-test was used to compare the variables. When nonparametric tests were needed, the Wilcoxon rank-sum test was applied.

The parametric Pearson Coefficient and the nonparametric Spearman's rank correlation coefficient were used to address the relationships between biometric parameters and the individual lifestyle variables

All analysis were performed using the SPSS v26.0 and JASP software's. All values are shown as mean ± standard deviation unless otherwise specified. All p-values (p) were 2-sided, and p-values < 0.05 were considered significant.

RESULTS

A total of 126 eyes from 63 individuals with a mean age at baseline of 14.2(+-2.6) years old were analyzed. At follow-up, the individuals with allergies history had eyes with a smaller VCL (16.425 VS 16.812, p0.08), lower R_VCL/AL at follow up (0.695 VS 0.701, p0.03) and less Δ_AL (0.087 VS 0.15 mm, p0.032) (**Table III**). Eyes with reported eye scratching habits had higher R_VCL/AL at follow up (0.700 VS 0.695, p0.08)(**Table IV)**. There was a correlation between weekly hours of outdoor activity with an increased VCL at follow up (Pearson 0.175, p 0.05)(**Table V**) and between daily hours spent on digital devices and Δ_R_VCL/AL (Pearson 0.177, p 0.048)(**Table V**).

DISCUSSION

The present study followed 63 teenagers for more than two years, including the Sars-Cov-19 pandemic, with Axial length (AL) measurements in two timepoints, as the most important descriptor of eye biometry in the setting of myopia progression[18]. Segmental biometric parameters, of which the Vitreous Cavity Length (VCL) is the most important in the axial myopia setting, were calculated. Additionally, we went further and calculated the relative proportion between the various segments - namely the VCL - and AL and the modification of these parameters during the follow-up – *ratios* and *deltas*. As the axial elongation of the eye that generates axial myopia occurs mainly in the posterior segment, the study of segmental biometrics is, according to the authors' belief, of the greatest importance, and presents itself as the main strength of the present study. At the authors knowledge, this is the first study with such characteristics. However, variations in the ratios over time are of a very small magnitude, and thus difficult to generate substantial differences.

The mean age at baseline in the present study was well within the range in which the difference between high myopias and those that develop mostly during the middle school years, the aforementioned school myopia, starts to highlight.[10]

The first important discussion is about the observation of AL growth (0.122mm) and also of the VCL(0.091mm) throughout the follow-up and at the authors knowledge this is the first description of a segmental biometrics progression in adolescents. However, the disproportion of VCL growth in relation to AL growth was only of a very small magnitude ($5{,}736\times10^{-5}$), but it is very important to be described.

The present study made an interindividual analysis regarding family history of myopia, history of allergies and ventral sleeping habits. Family history of ametropia is known as one of the main risk factors for an eye to be ametropic, namely in the setting of myopia.[3]However, in the present study, we didn´t find differences either in the baseline parameters or in the progression of biometric values in eyes from individuals with family history of myopia. Although an association between allergy and myopia has been described,[19,20] in the present study eyes from individuals with allergies history were not more myopic nor did they grow more than the others.On the contrary, we found greater AL growth during follow-up, with wider vitreous cavities but without disproportionate growth in eyes from individuals without allergies history. Although the relationship between sleep position and keratoconus is increasingly well known[21], there are no consistent descriptions of a possible relationship with myopic progression. Although the present study found greater both AL and VCL elongations in eyes from individuals with predominantly ventral sleeping position, it was not statistically significant and did not prove consistently the hypothesis that eyes with *pillow compression* could have greater axial or segmental elongation.

However, to the authors' knowledge, this was the first time it was studied in this way and we believe the present data may pave the way for further studies.

A per-eye analysis was made comparing eyes with ipsilateral sleeping position the other eyes. In this setting, the proposed *pillow compression* effect as a risk factor for myopia progression was not proven again, as AL and VCL increased less in these eyes, yet without statistical significance. Despite the other eyes being slightly smaller at baseline, and therefore with higher growth potential at this stage of life, it cannot be excluded that the *pillow effect* may function as a natural orthokeratology[22], being a protective factor against myopic progression as described in literature.

Within the per-eye analysis, the results from the variables *ocular surface symptoms* and *eye scratching habits* can be analyzed together. Although the second is more objective, in fact both variables are often associated, and this study is proof of that. Furthermore, this study brings alarming data, as we describe scratching habits in around 67% of eyes and ocular surface symptoms in around 44% of eyes, the second being a topic that has only begun to be addressed in recent years. Although we did not find statistically significant differences, it is important to note that both AL and VCL grew slightly more in eyes that were positive for each of the variables, even though these were eyes belonging to slightly older individuals and starting with slightly lower AL and VCL at baseline, therefore with a possible lower potential for growth. Rubbing eyes as a risk for keratoconus is well stablished in literature[23], however, when we focus in myopia, there are some new evidence about the differential changes in ocular biomechanics[24]but evidence is still scarce regarding the direct relationship with myopic progression. As there are few studies on dry eye in children, it is normal that its relationship with myopia is still poorly documented[25]. Given the described assumptions and the increasing prevalence of myopia and also dry eye disease, it will be of utmost importance in the future to study these entities and their possible relationship. Thus, data from the present study highlight the importance of the topic and may open new research horizons.

Finally, the present study tried to address correlations between biometrics and lifestyle variables during the follow-up. Firstly, it is important to mention that in our cohort, the daily time spent with digital screens is higher than that spent on reading/writing or physical activity. This is in line with the changes already described in the living habits of our children and we argue that it should be addressed with public health measures.[26] We found a weak positive correlation between *weekly hours of outdoor activity* and VCL both at baseline and at follow-up. Theoretically, these data are not in line with the most accepted evidence today, that sun exposure has an inverse relationship with myopia,[11,14] but it should be noted that sun exposure is subjective variable. On the other side, at the authors knowledge this is the first report of an association between VCL and sun exposure in children or adolescents. The role of physical activity, which is often related to sun exposure, is less consensual regarding any association with myopic progression.[13] The present study is in line with this, as we found no correlations between biometric parameters and *weekly hours of physical activity*.

The use of digital devices such as computers, tablets and smartphones has been studied as a potential risk factor for myopic progression, with some evidence already established, yet without consistency.[3,15,17,27] In the present study we found a positive weak correlation between *daily hours spent on digital devices* and the growth of the VCL in relation to the entire eye, which can be understood as a disproportionate growth of the posterior segment and, therefore, myopic progression. At the authors knowledge, this is the first work to describe this possible association

and has the added value of being based on a cohort followed up during the Covid pandemic, a time in which many of children's habits have changed, with some deleterious effects.[28]

Classically, time spent doing near work was associated with myopia[16,29-31]. In the present study, as authors tried to differentiate the potential effect of close work and digital devices, the chosen variable to measure specifically near work was *daily hours spent reading/writing*. We found very low amounts of near work in this sample and therefore we understand that it would be very difficult to find any type of association. In fact, we believe that nowadays much of this work is done on digital devices, making it increasingly difficult to study potential effect of the near work In the future, without the bias of using these devices.

The main strengths of the presentwork are the description of both axial and segmental biometrics in a cohort of adolescents at an age where myopic progression is common and the study of the direct relationship with lifestyle, in a time including the covid 19 pandemic, which exponentiated some behaviors potentially associated with this progression, such as decreased exposure to sunlight or increased use of digital devices. On the other hand, it has some limitations that must be described: the first is that data on lifestyle are derived from a questionnaire, with its associated subjectivity and which always tends to describe the most recent behaviors and not the most common throughout the entire follow-up period; the second is the acquisition of biometric data without cycloplegia, which can modify the calculations of segmental lengths, particularly of the vitreous cavity, due to changes in the lens resulting from accommodation.

CONCLUSION

The present study highlights the importance of lifestyle history and habits, namely those related with ocular surface, outdoor activity and digital devices, in the biometric status of the eye and its change over time, in young individuals during adolescence. It's relevant to note the connection between the usage of digital devices and the development of myopia. Some of the findings in this study were against the current knowledge in literature, something that may stem from the subjectivity of the answers in the questionnaire, and even more so with young people and adolescents, making for controversial results and more inconsistent reproducibility. Furthermore, this study it highlights the concept of analyzing the axial growth of the young eye from a sum of segments perspective. These data are important to help design effective strategies for the prevention of the global myopia epidemic in the upcoming decades and lead the direction of research of this topic.

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STATEMENT OF ETHICS

The study adhered to the tenets of the Declaration of Helsinki. Approval was obtained from the 'Departamento de Ensino, Formação e Investigação' (DEFI) of Centro Hospitalar e Universitário do Porto (nr: 130-DEFI-132-CE). The informed consent from the patients was waived due to the total anonymization and confidentiality of the data and the absence of detailed individual data.

DATA AVAILABILITY

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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