

RESEARCH

Open Access



Lens-induced myopization and body weight in young guinea pigs

Hao-Tian Wu¹, Xu-Han Shi¹, Li Dong¹, Zhang Rui-Heng¹, Yi-Tong Li¹ and Wen-Bin Wei^{1*}

Abstract

Background To investigate the relationship between body weight and Axial length in guinea pigs.

Methods Forty pigmented guinea pigs were randomly divided into two groups, namely control group and negative lens-induced myopization (LIM) group. After measuring the baseline axial length and body weight (BW), guinea pigs of LIM group received bilateral negative lens-induced myopization using -10.0 diopters lenses. One week later, the lenses were removed and biometric and ophthalmoscopic examinations were repeated.

Results Two groups of guinea pigs showed no statistical difference in initial body weight and eye axis length. Compared to the control group, the lens-induced group had a lower weight ($P=0.02$) and a longer axial length ($P<0.01$) at the end of study. Neither at baseline nor at week 1 did AL correlate with BW in both groups (Control Baseline: $r=0.306$, $P=0.19$; Control Week1: $r=0.333$, $P=0.15$; LIM Baseline: $r=-0.142$, $P=0.55$; LIM Week 1: $r=0.189$, $P=0.42$). Lens-induction had a significant effect on axial elongation ($P<0.01$) while body weight had no impact on such aspect ($P>0.05$).

Conclusion In guinea pigs of the same age, axial length was not correlated with body weight. Also, baseline body weight had no impact on natural axial length growth or lens-induced myopia. Lens-induction caused a significant reduction in body weight gain.

Keywords Axial length, Body weight, Lens-induced myopia

Introduction

The lens-induced myopia model of guinea pigs is one of the most studied myopia models in laboratory simulations. In such a model, axial length (AL) is considered as one of the major biological indicators of the degree of myopia. However, it is well known that axial length prolongs with individual growth and development early in

life, and the development of each individual differs from one another to a certain extent. Previous myopia experiments in guinea pigs also showed significant differences in eye axis between guinea pigs of the same age [1, 2]. Therefore, it is worth investigating whether these guinea pigs of the same age are at different stages of growth and development due to dietary and environmental factors and whether it is necessary to calibrate this possible bias when interpreting experimental results.

Body weight/Length is one of the important indicators of individual growth and development. Multiple studies have reported a significant association between body weight/height and axial length in children [3–5]. However, observed association between body weight and the onset of myopia might be confounded by lifestyle difference or environment exposures, such as the sedentary lifestyle. Therefore, in order to confirm the authenticity

*Correspondence:

Wen-Bin Wei
weibenbintr@163.com

¹ Beijing Tongren Eye Center, Beijing Key Laboratory of Intraocular Tumor Diagnosis and Treatment, Beijing Ophthalmology & Visual Sciences Key Lab, Medical Artificial Intelligence Research and Verification Key Laboratory of the Ministry of Industry and Information Technology, Beijing Tongren Hospital, Capital Medical University, 1 Dong Jiao Min Lane, Beijing 100730, China



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

of this finding, it is important to be able to reproduce it in a laboratory environment.

Since guinea pigs have no tails, we were unable to standardize the length of the subjects, as was done by Chakraborty et al. on mice [6]. Therefore, we chose body weight as a single indicator of its growth and development. The aim of this study was to investigate the relationship between growth and development in guinea pigs, as represented by body weight, and growth in axial length under natural and lens-induced conditions.

Methods

Animals and ethics

The experimental study included 40 male pigmented guinea pigs (*Cavia porcellus*) aged 2–3 weeks at baseline. The study was approved by the Ethics Committee of Beijing Tongren Hospital, and the ARVO Statement and ARRIVE Guidelines for the Use of Animals in Ophthalmic and Vision Research were followed. Animals were obtained from the Fang Yuan Farm in Beijing, China.

Study design

The animals were randomly divided into two groups and housed in 50*40*30 cm cages at a density of three per cage. Guinea pigs with the same treatment share the same cage. After measuring the baseline axial length and body weight of the two groups, the guinea pigs in LIM group received bilateral negative lens-induced myopia. As previously described in detail [7–9], goggles with a refractive power of -10.0 diopters were glued to the orbital rims of both eyes (Fig. 1), allowing the animals to open and blink freely. The animals were examined daily to ensure that the goggles were clean and in place. One week later, the goggles were removed and the axial length and body weight of both groups were repeated. At the end of the experiment, all animals were sacrificed by



Fig. 1 Guinea pig with bilateral lens induction

intraperitoneal injection of an overdose of pentobarbital sodium and their eyeballs were removed to be used as control material for other experiments.

Axial length and body weight measuring

The Axial length of the right eye of each subject was measured by ocular ultrasound biometry (A/B mode scan; oscillator frequency: 11 MHz; Quantel Co., Les Ulis, France) under topical anesthesia (Proparacaine hydrochloride eye drops; Alcon NV, Belgium). Ten measurements were performed, and the mean values were used for further statistical analysis if the standard deviations of the measurements were less than 0.1 mm.

Body weight of each guinea pig was measured by an electronic scale (Accuracy 0.01 g, experimental data rounded to one decimal place). Three measurements were performed, and the mean values were used for further statistical analysis if the standard deviations of the measurements were less than 1 g.

Statistics

For statistical analysis, we used a commercially available statistical analysis program (SPSS, version 26.0, IBM-SPSS, Chicago, IL, USA). Baseline axial length and body weight of the two groups were compared using two independent-sample T-test. The relationship between AL and BW at baseline and week 1 were analyzed by Pearson's correlation analyses. The effects of body weight and lens-induction on the elongation of the axial length were analyzed using univariate analysis of variance (UNI-ANOVA). A *P*-value of less than 0.05 was considered to be statistically significant.

Results

Baseline AL and BW of the two groups are shown in Table 1. Two groups showed no statistical difference in both baseline axial length and body weight.

Relationship between AL and BW

Neither at baseline nor at week 1 did AL correlate with BW (Fig. 2).

Table 1 Axial length and Body weight at baseline and week 1

	Axial length (mm)		Body weight (g)	
	Baseline	Week 1	Baseline	Week 1
Control group (n = 20)	7.95 ± 0.06	8.06 ± 0.07	140.5 ± 9.85	198.6 ± 7.38
LIM group (n = 20)	7.95 ± 0.06	8.16 ± 0.05	142.9 ± 9.95	192.1 ± 9.14
<i>P</i>	0.85	< 0.001	0.45	0.02

Data was expressed as mean ± standard deviation

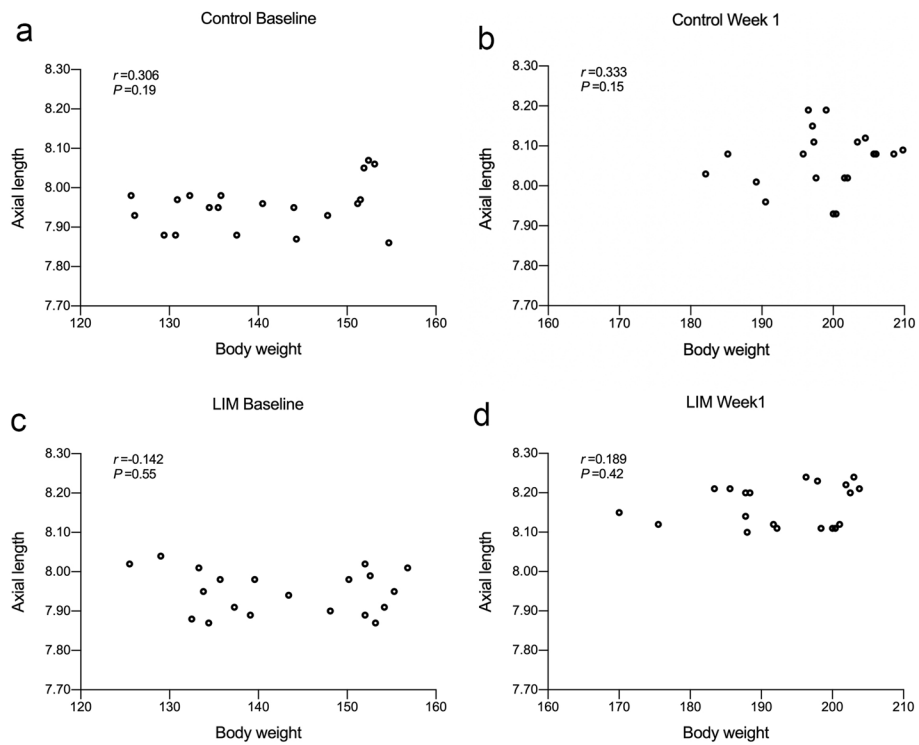


Fig. 2 Correlations between AL and BW at baseline and week 1. **a** Correlation between AL and BW of control group at baseline. **b** Correlation between AL and BW of control group at week 1. **c** Correlation between AL and BW of LIM group at baseline. **d** Correlation between AL and BW of LIM group at week 1

The effects of body weight and lens-induction on the elongation of the axial length

Lens-induction had a significant effect on axial elongation ($P < 0.01$), Body weight had no impact on axial length ($P > 0.05$, Fig. 3).

Discussion

There were complicated associations between myopia and body weight. Studies have shown that heavier children/adults tend to have longer AL, deeper vitreous chamber and flatter cornea than lighter persons of similar age and same sex [10]. However, they turn out to be

more hyperopic. This phenomenon may be due to a flatter cornea resulting in a lower refraction, which compensates to some extent for the myopic changes caused by a longer axial length of the eye.

We demonstrated for the first time that, in guinea pigs of the same age, axial length was not correlated with body weight. Also, baseline body weight had no impact on natural axial length growth or lens-induced myopia. This finding not only addressed the concern in many animal studies that there may be a correlation between body growth and axial length development in guinea pigs, but also suggests to some extent that eye growth is closely

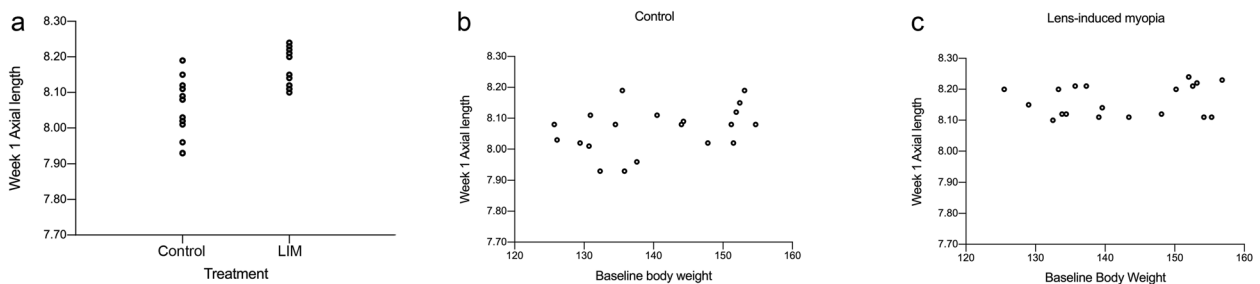


Fig. 3 Effects of body weight and lens-induction on axial length. **a** Axial length in control group and LIM group at week 1. **b, c** Relationship between baseline body weight and week 1 axial length in control and LIM groups

related to chronological age rather than general body development. It also supports the rationale for using age as the basis for grouping in many myopia-related clinical trials.

In addition, this study also suggests that the observed association between body weight and the onset of myopia might be confounded by some factors, such as a sedentary lifestyle. For example, greater weight may reflect certain lifestyle choices, such as less outdoor activity, and less outdoor activity has been shown to be significantly associated with axial growth [11, 12]. Therefore, long axial length, along with heavier weight, may only be the common result of such factors.

Finally, it is worth noting that during this study we found that the mean body weight of the lens-induced myopia group was significantly lower than that of the control group at the end of the experiment. However, without further testing, we were unable to determine whether the lens induction simply affected body weight gain in some way (e.g. by affecting the eating behavior of the guinea pigs) or whether the overall development of the guinea pigs in the lens induction group was slower than that of the control group. This phenomenon has never been reported before and deserves further investigation in future experiments.

Although this study provided important result of lens-induced myopization and body weight in young guinea pigs, it has some limitations. First of all, since the body length of the subject could not be accurately determined as previous study done in mice [6], we were unable to use BMI (body mass index) as a more accurate indicator of the body size of guinea pig. Secondly, due to the lack of reliability of currently available refractive index measurements, we did not perform refractive index measurements on our subjects. For reference, Howlett et al. suggests that for guinea pigs of the same age as those used in the present study, it is possible to convert on a scale of 0.1 mm=-6D [13]. Finally, the observation of the axial elongation was not prolonged, therefore, whether body weight effects the long-term outcome of guinea pigs could not be determined. However, according to Howlett & McFadden [13], guinea pigs reach sexual maturity at only 75 days, which is equivalent to a 12 year old human (an approximate age ratio of 20:1). In other words, our short one-week experiment is equivalent to 6 months (or more) of human myopia development for a 4- to 6-year-old human. Thus, the length of the present study, although not entirely satisfactory for the study of juvenile myopia progression, is sufficiently illustrative.

In conclusion, in guinea pigs of the same age, axial length was not correlated with body weight. Also, Baseline body weight had no impact on natural axial length growth or Lens-induced myopia. Further studies are

required to determine the long-term effect of body weight on axial length elongation that on axial growth of each individual subject. Lens-induction has a negative effect on body weight gain in guinea pigs, and further studies are needed to clarify the biological significance of this effect.

Nomenclature

BW = body weight [kg]

LIM = Lens Induced Myopia

AL = Axial length [mm]

BMI = Body Mass Index [kg/cm²]

Acknowledgements

Not applicable.

Declaration of interests

All authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors' contributions

Conception and design of the research: HTW, XHS and WBW; Acquisition and interpretation of the data: HTW, WBW and DL, RHZ, XHS; Statistical analysis and writing of the manuscript: HTW, DL and RHZ, YTL; Critical revision of the manuscript: HTW and WBW.

Funding

This study was supported by the National Natural Science Foundation of China (82220108017, 82141128); The Capital Health Research and Development of Special (2020-1-2052); Science & Technology Project of Beijing Municipal Science & Technology Commission (Z201100005520045, Z181100001818003).

Availability of data and materials

Data can be made available from the corresponding author on a reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Beijing Tongren Hospital, and the ARVO Statement and ARRIVE Guidelines for the Use of Animals in Ophthalmic and Vision Research were followed. This study also adhered to the tenets of the Basel Declaration.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 7 October 2023 Accepted: 19 December 2023

Published online: 03 January 2024

References

1. Wang Q, Ji X, Lu D, et al. Comparison of A-Scan ultrasonography and the Lenstar optical biometer in Guinea pig eyes. *Exp Eye Res.* 2021;207:108578.
2. Jiang L, Zhang S, Schaeffel F, et al. Interactions of chromatic and lens-induced defocus during visual control of eye growth in guinea pigs (*Cavia porcellus*). *Vis Res.* 2014;94:24–32.

3. Selovic A, Juresa V, Ivankovic D, et al. Relationship between axial length of the emmetropic eye and the age, body height, and body weight of schoolchildren. *Am J Hum Biol.* 2005;17(2):173–7.
4. Huang CY, Hou CH, Lin KK, et al. Relationship of lifestyle and body stature growth with the development of myopia and axial length elongation in Taiwanese elementary school children. *Indian J Ophthalmol.* 2014;62(8):865–9.
5. Terasaki H, Yamashita T, Yoshihara N, et al. Association of lifestyle and body structure to ocular axial length in Japanese elementary school children. *BMC Ophthalmol.* 2017;17(1):123.
6. Chakraborty R, Park HN, Tan CC, et al. Association of body length with ocular parameters in mice. *Optom Vis Sci.* 2017;94(3):387–94.
7. Morgan IG, Ashby RS, Nickla DL. Form deprivation and lens-induced myopia: are they different? *Ophthalmic Physiol Opt.* 2013;33(3):355–61.
8. Dong L, Shi XH, Li YF, et al. Blockade of epidermal growth factor and its receptor and axial elongation in experimental myopia. *FASEB J.* 2020;34(10):13654–70.
9. Dong L, Zhang RH, Zhou WD, et al. Epiregulin, epigen and betacellulin antibodies and axial elongation in young guinea pigs with lens-induced myopization. *BMC Ophthalmol.* 2022;22(1):193.
10. Wu HM, Gupta A, Newland HS, et al. Association between stature, ocular biometry and refraction in an adult population in rural Myanmar: the Meiktila eye study. *Clin Exp Ophthalmol.* 2007;35(9):834–9.
11. He M, Xiang F, Zeng Y, et al. Effect of Time Spent Outdoors at School on the development of myopia among children in China: a Randomized Clinical Trial. *JAMA.* 2015;314(11):1142–8.
12. Wu PC, Tsai CL, Wu HL, et al. Outdoor activity during class recess reduces myopia onset and progression in school children. *Ophthalmology.* 2013;120(5):1080–5.
13. Howlett MH, McFadden SA. Spectacle lens compensation in the pigmented guinea pig. *Vis Res.* 2009;49(2):219–27.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

