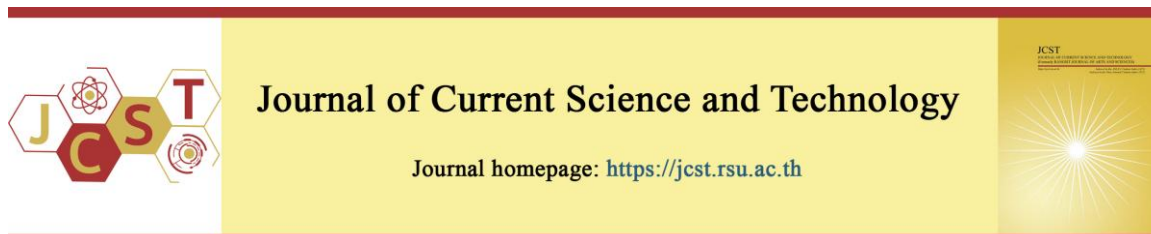


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Prevalence of Myopia and Its Association with Indoor and Outdoor Sport Participation among University Student Athletes in Thailand

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Abstract

Myopia is a growing public health problem in East and Southeast Asia, but evidence among university athletes remains limited. This cross-sectional study determined the prevalence of myopia among amateur university athletes at Rangsit University, Thailand, and examined associations with sport environment and selected risk factors. A total of 157 athletes (115 males, 42 females; mean age 19.79 ± 1.88 years) completed a demographic questionnaire and underwent axial length measurement, slit-lamp biomicroscopy, non-mydratic fundus photography, autorefraction, and manifest refraction. Myopia was defined as a spherical equivalent ≤ -0.50 D using the more myopic eye. Sports were classified as indoor or outdoor according to the primary training and competition environment. Multivariable logistic regression was used to assess associations with family history of myopia, sport environment, sleep duration, years of athletic practice, daily training duration, and gender. Overall myopia prevalence was 51.60% (81/157). A positive family history was associated with higher odds of myopia (AOR = 2.53; 95% CI: 1.25–5.12; $p = 0.010$). After adjustment, indoor sport participation was associated with higher odds compared with outdoor sport participation (AOR = 2.44; 95% CI: 1.14–5.23; $p = 0.021$). Sleeping >6 hours per day was protective (AOR = 0.37; 95% CI: 0.18–0.79; $p = 0.010$). Gender, years of practice, and daily training duration were not significant predictors. These findings suggest that regular sports participation alone may not offset myopia risk when training occurs mainly indoors. Vision screening for student-athletes should consider family history, sport environment, and sleep habits.

Keywords: myopia prevalence, university athletes, sport vision, indoor sports, outdoor sports, family history, sleep duration, refractive error

1. Introduction

Myopia, or nearsightedness, has emerged as one of the most pressing global public health concerns of the twenty-first century. A comprehensive systematic review and meta-analysis by Liang et al. (2025), encompassing 276 studies and over 5.4 million participants from 50 countries, reported that the global prevalence of myopia in children and adolescents increased from approximately 24% in 1990 to nearly 36% by 2023, with projections

indicating that it will approach 40% by 2050. The burden of myopia is disproportionately concentrated in East and Southeast Asia, where prevalence rates in young adults have been documented at 80–90% in urbanized populations (Morgan, 2024). Although the epidemic has been most extensively studied in East Asian countries such as China, Taiwan, and South Korea, recent evidence suggests that several Southeast Asian nations, including Thailand and

Indonesia, may be approaching similarly elevated levels of myopia in young adults (Morgan, 2024).

In Thailand specifically, the epidemiological picture is evolving rapidly. Earlier studies reported a myopia prevalence of approximately 11.1% among school-aged children (ages 6 – 12), but more recent data from university-aged populations, including medical and nursing students in Bangkok, indicate rates approaching 50% (Poovichayasumlit & Khewnoparatana, 2024). Comparable trends have been observed in neighboring Southeast Asian countries: Singapore reports myopia prevalence exceeding 80% in young adults, and Vietnam and Malaysia report rates of 40 – 60% in the same age group (Morgan, 2024). Despite this regional trajectory, population-specific data for Thai university athletes, a group that may have distinct risk and protective factor profiles, remain absent from the literature.

The etiology of myopia is multifactorial, involving a complex interplay between genetic susceptibility and environmental exposures. Genetic factors play a foundational role, with parental myopia being one of the strongest and most consistently identified risk factors across diverse populations. Genome-wide association studies have identified over 70 genetic loci associated with myopia (Tedja et al., 2019), and twin studies demonstrate high heritability estimates (Hammond et al., 2001). Jones et al. (2007) further showed that parental history of myopia was an important predictor of juvenile-onset myopia, with a differential protective effect of sports and outdoor activity depending on the number of myopic parents. Concurrently, environmental factors have become increasingly recognized as critical contributors to the current epidemic. Among these, limited time spent outdoors, intensive near work, prolonged screen time, high academic demands, and reduced physical activity have all been implicated (Morgan et al., 2021; Ha et al., 2025; Czepita et al., 2017). The protective effect of outdoor exposure is supported by robust evidence from randomized controlled trials, with the prevailing hypothesis being that bright outdoor light stimulates the release of retinal dopamine, which in turn inhibits excessive axial elongation of the eye (Rose et al., 2008; Zhou et al., 2017; Muralidharan et al., 2021). Specifically, outdoor illuminance is highly context-dependent. Lanca et al. (2019) reported 11,080 - 18,176 lux outdoors versus 112 - 156 lux indoors; even with hats or sunglasses, outdoor illuminance remained 11 - 43 times higher than indoor levels. An updated review by the International Myopia Institute (IMI) further confirmed that

although light intensity is a key factor, the precise mechanisms, including the roles of spectral composition, temporal patterns, and vitamin D, remain active areas of investigation (Morgan et al., 2021).

Myopia has direct implications for athletic performance. Clear vision, encompassing static and dynamic visual acuity, contrast sensitivity, depth perception, and peripheral awareness, is essential for sport-specific tasks such as tracking moving objects, judging distances, and executing rapid motor responses (Mann et al., 2007; Zimmerman et al., 2011). A systematic review by Buscemi et al. (2024) confirmed that visual processing and reaction speed are among the key factors distinguishing excellent athletic performance and that sport-specific visual skills are trainable through structured vision training programs. Refractive errors, particularly myopia, can impair these visual capabilities, potentially hindering performance and safety (Jaradaroonthay et al., 2024). In a large European survey of amateur athletes, Zeri et al. (2018) reported that 38.2% had a visual defect, with myopia being the most prevalent at 31.2%. Critically, their logistic regression analysis showed that participation in outdoor sports was associated with a lower prevalence of myopia than participation in indoor sports. Similarly, Zhang et al. (2022), in a study of 1,401 young sport-related individuals in Tianjin, China, found an overall myopia prevalence of 50.18%, with indoor athletes having significantly higher odds of myopia than outdoor athletes (adjusted OR = 1.79; 95% CI: 1.39 – 2.30). These findings suggest that the type of sporting environment may influence refractive status through differential outdoor light exposure.

Despite the growing body of literature on myopia epidemiology and its environmental risk factors, several important research gaps remain that the present study aims to address:

First, the vast majority of studies examining the relationship between sport type and myopia have been conducted among professional athletes, schoolchildren, or general populations in East Asian countries, particularly China (Zhang et al., 2022). Very few studies have focused specifically on amateur university-level athletes, a population uniquely exposed to the dual demands of intensive academic work and regular sports training. This combination may create a distinctive risk profile for myopia that differs from those of both the general student population and professional athletes.

Second, data from Southeast Asian populations remain scarce. Although myopia prevalence in East Asian young adults has been extensively documented, recent analyses suggest that Southeast Asia, including Thailand, may be on the cusp of a similar epidemic; however, epidemiological data for Thai university athletes are virtually absent (Morgan, 2024). Understanding the prevalence and risk factors of myopia in this specific population is essential for developing culturally and regionally appropriate screening and prevention programs.

Third, although the protective role of outdoor activity against myopia onset has been well established in pediatric populations through randomized controlled trials, whether this protective effect extends to university-aged athletes who are already engaged in regular sports training, and whether the indoor or outdoor setting of their sport makes a measurable difference, remains inadequately explored. Most existing studies do not differentiate between sport-related outdoor time and total outdoor exposure, nor do they account for the confounding effects of non-training academic activities common among university students. Moreover, evidence remains limited regarding whether the protective effect of outdoor sports persists after controlling sleep duration and genetic predisposition simultaneously in a multivariable model.

Fourth, the interplay between genetic predisposition (particularly family history of myopia) and modifiable lifestyle factors such as sleep duration, training hours, and sport type has not been systematically examined in athletic populations. Understanding how these factors interact in university athletes could inform more personalized and effective vision care strategies.

2. Objectives

The primary objective of this study was to determine the prevalence of myopia among amateur university athletes at Rangsit University, Thailand. The secondary objective was to examine whether family history of myopia, sport environment, sleep duration, years of athletic practice, daily training duration, and gender were associated with myopia. The study hypothesized that positive family history of myopia and indoor sport participation would be associated with higher odds of myopia, whereas longer sleep duration would be associated with lower odds of myopia.

3. Materials and Methods

3.1 Study Design and Ethical Approval

A cross-sectional study was conducted among amateur athletes at Rangsit University, Pathumthani, Thailand. The study protocol was reviewed and approved by the Research Ethics Office of Rangsit University on June 26, 2024 (COA No. RSUERB2024-107). All procedures adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants before data collection. Data were collected between July and August 2024. The overall study design is summarized in the flowchart presented in Figure 1.

3.2 Study Population

3.2.1 Inclusion Criteria

Participants were eligible for inclusion if they met the following criteria: (1) aged 18 years or older, ensuring legal adulthood and the capacity to provide informed consent; (2) registered as amateur athletes at Rangsit University at the time of data collection; (3) willing to complete a demographic questionnaire covering family history, sleep habits, and sports participation; and (4) willing to undergo all scheduled eye examinations.

3.2.2 Exclusion Criteria

Participants were excluded if they had any of the following: (1) previous refractive or ocular surgery; (2) best-corrected visual acuity worse than 20/20; or (3) systemic or ocular diseases known to influence visual acuity or refractive error, including diabetes mellitus, cataract, thyroid disease, or corneal dystrophy. These criteria were used to minimize confounding from surgical, systemic, or ocular conditions that could affect refractive status.

3.2.3 Sample Size Considerations

All eligible amateur athletes from the available university cohort during the study period were invited to participate, resulting in a final sample size of 157 participants. Although the lack of an a priori power analysis is acknowledged as a limitation, a post-hoc power analysis was performed. With $N = 157$, the study demonstrated adequate statistical power (over 80%) to detect the strong significant associations identified in the multivariable model, specifically for family history and indoor sport participation.

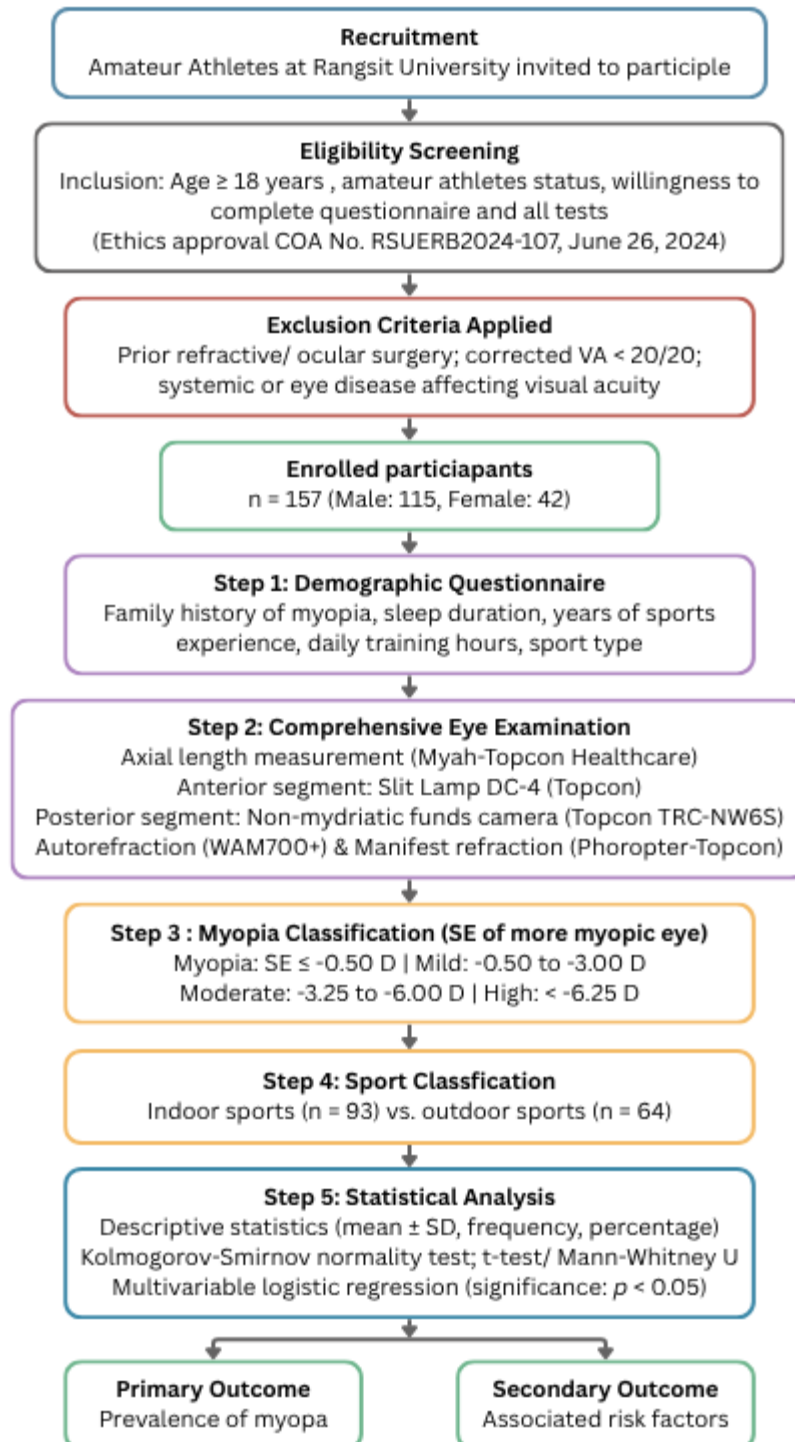


Figure 1 Study flow chart illustrating the participant recruitment, data collection procedures, and analytical framework
Note: SE = Spherical Equivalent; D = Diopters; VA = Visual Acuity. All ophthalmic instruments were manufactured by Topcon Healthcare unless otherwise stated.

3.3 Data Collection Procedures

3.3.1 Demographic Questionnaire

Each participant completed a structured demographic questionnaire that collected information on the following variables: age, sex, body weight, height, years of sports experience, daily training hours, type of sport practiced, daily sleep duration, and family history of myopia. A positive family history was defined as having at least one biological parent diagnosed with myopia, consistent with standard methods for assessing genetic risk in epidemiological studies of myopia (Dirani et al., 2009; Jones et al., 2007). Before implementation, the questionnaire was evaluated for content validity by a panel of experts. The Item-Objective Congruence (IOC) index was 0.93, indicating strong validity and appropriateness for the study's objectives. The questionnaire was pilot-tested on a convenience sample of 10 athletes not included in the main study to assess clarity and completion time. Minor wording adjustments were made based on pilot feedback before final implementation.

3.3.2 Comprehensive Eye Examination

All eye examinations were performed by two trained optometrists following a standardized protocol. The examination protocol included the following components:

Axial length measurement: Axial length was measured using the Myah biometer (Topcon Healthcare). This measurement provides an objective biometric parameter that is strongly correlated with the degree of myopia.

Anterior segment assessment: The anterior segment was examined using the DC-4 Slit Lamp biomicroscope (Topcon Healthcare) to evaluate the health of the cornea, anterior chamber, iris, and crystalline lens, and to identify any pathology that might warrant exclusion from the study.

Posterior segment evaluation: The posterior segment was assessed using the TRC-NW6S non-mydriatic fundus camera (Topcon Healthcare). This examination was conducted to screen for retinal abnormalities, including those associated with pathological myopia.

Objective refraction: Automated refraction was performed using the WAM-700+ Wave Analyzer Medica (Essilor), which provided an initial objective measurement of the participant's refractive error.

Subjective (manifest) refraction: Manifest refraction was subsequently performed using a Phoropter (Topcon Healthcare) to refine the refractive error measurement. The final spherical equivalent (SE) was calculated using the following formula:

$$SE = \text{sphere} + \left(\frac{\text{Cylinder}}{2} \right) \quad (1)$$

where sphere and cylinder were measured in diopters.

3.4 Definitions and Classifications

3.4.1 Definition of Myopia

Myopia was defined as a spherical equivalent (SE) refraction of ≤ -0.50 diopters (D) in at least one eye, in accordance with the standards established by the International Myopia Institute (Flitcroft et al., 2019; Jenchitr & Jaradaroonchay, 2021). To analyze myopia status, the SE value from the participant's more myopic eye was used, as this approach captures any myopia present and allows for a comprehensive assessment of prevalence within the cohort (Czepita et al., 2007). Myopia severity was categorized as mild myopia ($SE \leq -0.50$ D to > -3.00 D), moderate myopia ($SE \leq -3.00$ D to > -6.00 D), and high myopia ($SE \leq -6.00$ D). This classification system is consistent with widely used standards in clinical and epidemiological myopia research (Holden et al., 2016; Flitcroft et al., 2019).

3.4.2 Sport Classification

Sports were classified as indoor or outdoor according to the primary training and competition environment used by the university teams. Classification was based on whether the sport was typically performed in an enclosed or climate-controlled facility, whether artificial or natural light predominated, and whether the playing surface was primarily indoor or outdoor. For transparency, all sports represented in the study were classified before analysis and are presented in Table 1. For example, Badminton was classified as an indoor sport because it is typically played in enclosed, climate-controlled gymnasiums with artificial flooring and smaller team sizes, whereas soccer (football) was classified as an outdoor sport because it is primarily played on large natural grass fields exposed to ambient weather and sunlight. This approach was applied consistently to all 13 sports represented in the study to enhance construct validity and ensure reliable classification of the exposure variable.

Table 1 Distribution of athletes by type of sport (N = 157)

Type	Sport	n	Percentage (%)
Indoor	Basketball	20	12.74
	Judo-jujitsu	18	11.46
	E-Sport	16	10.19
	Volleyball	14	8.92
	Badminton	12	7.64
	Taekwondo	10	6.37
	Table Tennis	5	3.18
Outdoor	Football	41	26.11
	Petanque	9	5.73
	Tennis	4	2.55
	Swimming	4	2.55
	Athletics	3	1.91
	Golf	1	0.64
	Total	157	100.00

3.4.3 Sleep Duration Classification

For the analysis of sleep habits, daily sleep duration was dichotomized into two categories: ≤ 6 hours and > 6 hours per day. This specific 6-hour cut-off was chosen based on established epidemiological evidence indicating that sleeping 6 hours or less represents a critical threshold for sleep deprivation in young adults (Hirshkowitz et al., 2015). In the context of visual health, studies have demonstrated an inverse relationship between sleep duration and myopia, identifying ≤ 6 hours as a significant risk factor for visual fatigue, insufficient ciliary muscle relaxation, and altered ocular circadian rhythms, all of which may contribute to refractive error progression (Jee et al., 2016; Jin et al., 2024). Therefore, dichotomizing at this threshold allows for a clear clinical distinction between student-athletes experiencing severe sleep restriction and those achieving relatively adequate rest.

3.5 Statistical Analysis

Data were collected and organized using Microsoft Excel 2021, and all statistical analyses were performed using SPSS Statistics software version 24. Descriptive statistics were used to summarize participant characteristics, including frequency distributions, percentages, means, and standard deviations. The normality of continuous variables was assessed using the Kolmogorov–Smirnov test. Normally distributed data were expressed as mean $\pm$ standard deviation (SD), and group comparisons were performed using the independent-samples t-test. For non-normally distributed data, the median and interquartile range (IQR) were reported, and group comparisons were conducted using the Mann–Whitney U test.

Multivariable logistic regression analysis was used to evaluate factors associated with myopia status. Myopia was coded as the outcome variable [myopia = 1, non-myopia = 0]. The independent variables entered into the model were family history of myopia, years of athletic practice, daily training duration, sleep duration, sport environment, and gender. Adjusted odds ratios (AORs), 95% confidence intervals, and p-values were reported. Multicollinearity was assessed using the variance inflation factor (VIF), and model fit was evaluated using the Hosmer–Lemeshow goodness-of-fit test. Statistical significance was set at $p < 0.05$.

4. Results

4.1 Demographic and Biometric Characteristics

A total of 157 amateur athletes were included in the study. The demographic and biometric characteristics are shown in Table 2. The mean age of the participants was 19.79 ± 1.88 years. The mean height was 173.18 ± 8.15 cm. The median body weight was 65.0 kg (IQR: 57.5 – 75.0), and the median years of sports experience was 8.0 years (IQR: 6.0 – 10.0). The median spherical equivalent was -0.51 D (IQR: -1.54 to -0.13), indicating a generally myopic distribution. The median axial length was 23.93 mm (IQR: 23.36 – 24.64). These baseline characteristics indicate that the sample consisted primarily of young adult athletes with several years of sports experience.

Among myopic participants, the mean axial length was 24.43 ± 1.00 mm, compared with 23.28 ± 1.81 mm in non-myopic participants ($p < 0.001$). A significant positive correlation was observed between axial length and myopia severity ($r = 0.35$; $p < 0.001$), confirming that the refractive findings were structurally consistent with axial elongation.

4.2 Prevalence and Severity of Myopia

The overall prevalence of myopia ($SE \leq -0.50$ D) among the athletes was 51.60% ($n = 81$ out of 157; 95% CI: 43.79 – 59.41). As detailed in Table 3, among those diagnosed with myopia, the majority were classified as having mild myopia (77.78%, $n = 63$), defined as SE between -0.50 D and -3.00 D. Moderate myopia ($SE \leq -3.00$ D to > -6.00 D) accounted for 16.05% ($n = 13$) of myopic cases, while high myopia ($SE \leq -6.00$ D) was present in 6.17%. This distribution indicates that although myopia is highly prevalent in this athletic population, most affected individuals exhibit a mild degree, with a smaller but clinically important proportion demonstrating moderate to high myopia that may carry additional risks for ocular complications.

Table 2 Demographic and biometric characteristics of amateur athletes (N = 157)

Variable	Mean $\pm$ SD	Median (IQR)
Age (years)	19.79 $\pm$ 1.88	19.00 (18.00–21.00)
Weight (kg)	68.06 $\pm$ 14.34	65.00 (57.50–75.00)
Height (cm)	173.18 $\pm$ 8.15	174.00 (167.00–180.00)
Years of Sports Experience	8.14 $\pm$ 3.61	8.00 (6.0–10.0)
Spherical Equivalent (D)	−1.10 $\pm$ 1.64	−0.51 (−1.54 to −0.13)
Axial Length (mm)	23.87 $\pm$ 1.56	23.93 (23.36–24.64)

Table 3 Prevalence and severity of myopia among amateur athletes (N = 157)

Category	n	Percentage (%)
Total Participants	157	100
Myopia Cases	81	51.60
Mild Myopia	63	77.78
Moderate Myopia	13	16.05
High Myopia	5	6.17

Note: Prevalence percentages (Total Participants, Myopia Cases) are calculated from the full sample (N = 157); severity percentages (mild, moderate, high) are calculated within myopic cases (n = 81)

4.3 Distribution of Participants by Sports Type

Participants were categorized as indoor or outdoor athletes according to their primary sport environment. Indoor athletes accounted for n = 95 (60.51%) participants, whereas outdoor athletes accounted for n = 62 (39.49%) participants. The distribution of participants by sport is shown in Table 1. Football was the most commonly represented sport, followed by basketball and judo-jujutsu.

4.4 Myopia Prevalence by Sports Type

A comparison of myopia prevalence between indoor and outdoor athletes is presented in Table 4. Among the 95 indoor athletes, 54 (56.84%) were myopic, whereas among the 62 outdoor athletes, 27 (43.55%) were myopic. These figures indicate a higher descriptive prevalence of myopia among indoor athletes than outdoor athletes. However, this crude difference did not reach statistical significance in the chi-square test. The association between sport environment and myopia emerged after adjustment for other risk factors in the multivariable logistic regression model (Table 5), where indoor sport participation was significantly associated with higher odds of myopia ($p = 0.021$).

Table 4 Myopia prevalence by sports type (n = 157)

Sports Type	Total Athletes	Myopia Cases	Myopia (%)
Indoor Sports	95	54	56.84
Outdoor Sports	62	27	43.55

Note: Percentages are row percentages within each sport type

A chi-square test of independence showed that the difference in myopia prevalence between indoor and outdoor athletes was not statistically significant at the univariable level ($\chi^2 = 2.65$, $df = 1$, $p = 0.103$).

4.5 Association Between Risk Factors and Myopia

Multivariable logistic regression analysis was performed to evaluate the independent association of several factors with the presence of myopia. The adjusted model (Table 5 and Figure 2) revealed three statistically significant predictors. The strongest predictor was a positive family history of myopia. Athletes with at least one myopic parent had 2.53 times the odds of having myopia compared with those with no family history (AOR = 2.53; 95% CI: 1.25–5.12; $p = 0.010$).

Sport type was also a significant predictor after adjustment. Athletes participating in indoor sports had 2.44 times the odds of being myopic compared with their counterparts in outdoor sports (AOR = 2.44; 95% CI: 1.14–5.23; $p = 0.021$). This association emerged after adjustment for family history of myopia, sleep duration, years of athletic practice, daily training duration, and gender; the estimated effect strengthened from a crude OR of 1.71 to an AOR of 2.44, suggesting negative confounding in the unadjusted comparison.

Sleep duration was also a significant protective factor. Athletes who slept more than six hours per day had a 63% reduction in the odds of having myopia compared with those sleeping six hours or less (AOR = 0.37; 95% CI: 0.18–0.79; $p = 0.010$).

Other factors did not reach statistical significance in the adjusted model. The association for years of athletic practice showed a trend toward significance ($p = 0.055$), suggesting a possibly weak protective effect for longer experience. Neither daily training duration ($p = 0.770$) nor gender ($p = 0.811$) was significantly associated with myopia in this cohort.

The final multivariable logistic regression model demonstrated acceptable fit based on the Hosmer–Lemeshow goodness-of-fit test ($\chi^2 = 1.337$,

df = 8, $p = 0.995$). The area under the receiver operating characteristic curve was 0.698 (95% CI: 0.62 – 0.78), indicating fair discriminatory ability,

approaching the acceptable range. The Nagelkerke R^2 was 0.155. Multicollinearity was not a concern, as all VIF values were below 2.0.

Table 5 Crude and multivariable logistic regression analysis of factors associated with myopia among amateur athletes (N = 157)

Factors	Without Myopia; n (%)	Myopia; n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)	P-value
Family history of myopia					
No	54 (71.10%)	43 (53.10%)	reference	reference	0.010
Yes	22 (28.90%)	38 (46.90%)	2.17 (1.12–4.20)	2.53 (1.25 – 5.12)	
Years of athletic practice					
≤ 8	36 (47.40%)	49 (60.50%)	reference	reference	0.055
> 8	40 (52.60%)	32 (39.50%)	0.59 (0.31–1.11)	0.51 (0.25 – 1.02)	
Daily training duration (hours)					
≤ 2	34 (44.70%)	32 (39.50%)	reference	reference	0.770
> 2	42 (55.30%)	49 (60.50%)	1.24 (0.66–2.34)	1.11 (0.55 – 2.26)	
Sleep duration (hours/day)					
≤ 6	33 (43.40%)	57 (70.40%)	reference	reference	0.010
> 6	43 (56.60%)	24 (29.60%)	0.32 (0.17–0.62)	0.37 (0.18 – 0.79)	
Sport Location					
Outdoor	35 (46.05%)	27 (33.30%)	reference	reference	0.021
Indoor	41 (53.95%)	54 (66.70%)	1.71 (0.90–3.26)	2.44 (1.14 – 5.23)	
Gender					
Female	20 (26.30%)	22 (27.20%)	reference	reference	0.811
Male	56 (73.70%)	59 (72.80%)	0.96 (0.47–1.94)	0.91 (0.42 – 1.98)	

Note: Percentages are column percentages within myopia status. Crude odds ratios are unadjusted estimates. Adjusted odds ratios and p -values are from the multivariable logistic regression model. Values of $p < 0.05$ were considered statistically significant

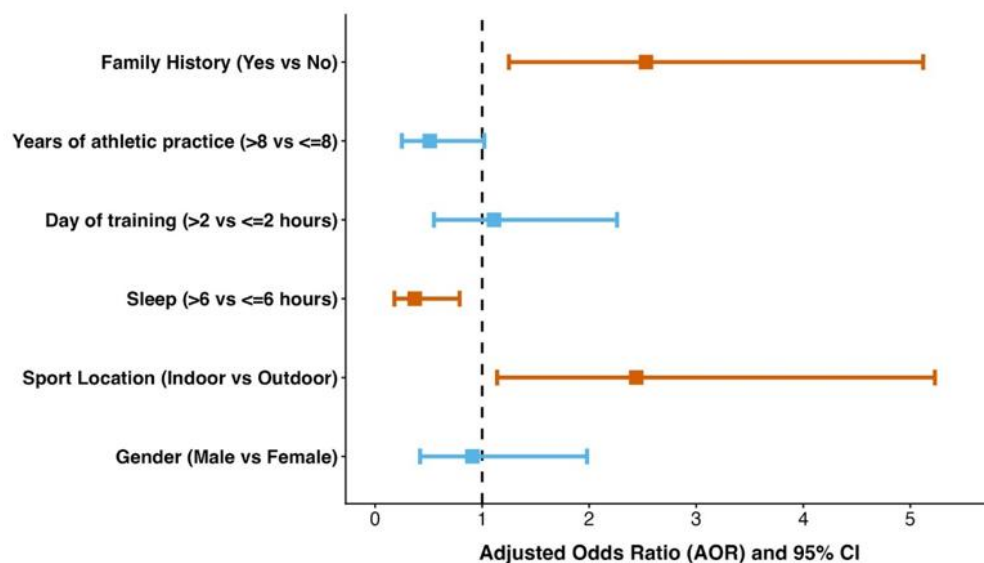


Figure 2 Forest plot illustrates the multivariable logistic regression analysis of factors associated with myopia. The markers represent adjusted odds ratios, and the horizontal lines represent 95% confidence intervals. The vertical dashed line at 1.0 indicates the line of no effect. Values with 95% confidence intervals that do not cross 1.0 are considered statistically significant at $p < 0.05$

5. Discussion

This study examined the association between myopia and the types of sports played by amateur athletes at Rangsit University, as well as other potential associated factors. The main findings and their implications are discussed below in relation to existing literature.

5.1 High Prevalence of Myopia Among University Athletes

The overall myopia prevalence of 51.60% observed in our cohort is notably higher than the 31.2% reported by Zeri et al. (2018) in a general European sports-playing population. However, it is comparable to the approximately 50% prevalence reported among medical and nursing students in Bangkok (Poovichayasumlit & Khewnoparatana, 2024). The high prevalence in our sample likely reflects a combination of factors, including the high baseline myopia rate in Southeast Asian populations and the academic demands placed on university students, both of which may contribute to an elevated refractive error burden even among physically active individuals. For regional context, myopia prevalence in young adults has been reported at over 80% in Singapore (Wu et al., 2001), approximately 47 – 60% in Malaysia (Goh et al., 2005), and 40 – 55% in Vietnam (Paudel et al., 2014). Our finding of 51.60% in Thai university athletes is therefore consistent with the broader Southeast Asian trajectory of escalating myopia prevalence, suggesting that Thailand is following the regional pattern despite having historically lower reported rates. Ultimately, these data suggest that regular sports participation alone is insufficient to mitigate the myopia risks associated with genetic susceptibility and the intensive near-work behaviors typical of higher education environments.

5.2 Family History as a Predominant Risk Factor

The most significant finding of this study is the strong association between a positive family history and the likelihood of developing myopia (AOR = 2.53). Athletes with at least one myopic parent were approximately twice as likely to be myopic, aligning with robust evidence from genetic studies, including the twin-eye study by Hammond et al. (2001), which demonstrated that heredity accounts for a substantial proportion of the variance in refractive error. Although environmental factors such as near work and limited outdoor exposure are also strongly implicated in childhood and adolescent myopia

(Dirani et al., 2009), our findings reinforce that genetic predisposition remains the predominant and most consistent risk factor, particularly in populations where environmental exposures are relatively homogeneous, as is the case among athletes at a single university.

5.3 Sleep Duration and Myopia Progression

A key finding of this study is the statistically significant protective effect of longer sleep duration against myopia. Athletes who reported sleeping more than six hours per day demonstrated a 63% reduction in the odds of myopia compared to those sleeping fewer hours (AOR = 0.37; 95% CI: 0.18–0.79; $p = 0.010$). This outcome is highly relevant for student-athletes, who navigate the dual constraints of intensive academic near-work and demanding physical training schedules. Identifying modifiable protective behavioral factors is therefore critical for this unique cohort.

5.3.1 Mechanisms of Accommodative Relaxation

While the exact etiology remains complex, a primary mechanism may involve the alleviation of cumulative visual fatigue and ciliary muscle strain. During sleep, the ocular accommodative system can fully relax, reducing both hyperopic defocus and accommodative stress-factors heavily implicated as stimuli for axial elongation and myopia progression (Ayaki et al., 2016). These biological plausibilities align with evidence from younger cohorts; for example, a systematic review and meta-analysis by Jin et al. (2024) confirmed an association between shorter sleep duration and an increased prevalence of myopia in children and adolescents.

5.3.2 Circadian Regulation and Ocular Growth

A secondary, complementary biological mechanism involves the circadian regulation of ocular growth. The eye exhibits diurnal rhythms of axial length variation, characterized by daytime elongation and partial nocturnal recovery (Chakraborty et al., 2018). Adequate sleep supports this nocturnal recovery phase, potentially enabling the eye to resist cumulative daytime axial elongation. Conversely, chronic sleep restriction, common among student-athletes disrupts systemic melatonin secretion and circadian clock gene expression within ocular tissues, which may alter the eye's sensitivity to emmetropization signals (Nickla & Wallman, 2010; Zhang et al., 2026).

Consequently, sleep deprivation represents a compounding risk factor that may accelerate myopia

progression. Given the strength of this association, these findings suggest that public health initiatives and clinical counseling targeting university students should emphasize sufficient sleep as an accessible, non-invasive strategy to mitigate myopia risk.

5.4 Indoor Versus Outdoor Sports and Myopia

The adjusted analysis suggested an independent association between sport environment and myopia risk. Although the crude chi-square comparison showed a higher myopia prevalence among indoor athletes than outdoor athletes without reaching statistical significance, the association became statistically significant after adjustment for family history of myopia, sleep duration, years of athletic practice, daily training duration, and gender. Athletes primarily participating in indoor sports demonstrated more than double the adjusted odds of myopia compared with their outdoor counterparts (AOR = 2.44; 95% CI: 1.14 – 5.23; $p = 0.021$). This finding is consistent with the light-dopamine hypothesis, which posits that exposure to high-intensity natural light is a critical protective factor against myopia development and progression (Rose et al., 2008; Xiong et al., 2017).

The Light-Dopamine Mechanism

The mechanism underlying this protective effect is directly linked to the profound disparity in illuminance between the two environments. Natural outdoor illuminance varies substantially by weather, time, location, and shading. In the outdoor settings assessed by Lanca et al. (2019), illuminance was 11,080 – 18,176 lux, compared with 112–156 lux indoors; even with hats or sunglasses, outdoor illuminance remained 11–43 times higher than indoor levels. High-intensity light exposure, particularly in the blue-violet spectrum, stimulates the release of retinal dopamine from amacrine cells. Increased retinal dopamine acts as an inhibitory signal for ocular growth, preventing the excessive axial elongation that characterizes progressive myopia (Zhou et al., 2017). Consequently, indoor athletes are systematically deprived of this light-dependent protective cascade, which elevates their refractive risk, a finding consistent with large-scale studies in other athletic populations (Zhang et al., 2022).

Environmental Proxies and Attenuation

Although sport classification served as a significant predictor in this model, it functions as a proxy for total outdoor light exposure. Cumulative time spent outdoors during leisure, commuting, and

social activities ultimately dictates total light volume. Because university athletes across both cohorts spend considerable time indoors for academic activities, this shared environmental exposure may partially attenuate the observed differences between the groups (Limwattanayingyong et al., 2022). Nevertheless, the persistence of a statistically significant association underscores the substantial independent impact of the training environment. Simply participating in sports is not inherently protective; the environment in which the activity occurs is a decisive factor.

Methodological Considerations and Selection Bias

A critical interpretive challenge regarding the indoor/outdoor sport association is the potential for reverse causality. Individuals who developed myopia during childhood may preferentially self-select into indoor sports. Myopes may favor indoor environments where managing corrective lenses is more convenient, environmental factors like glare and wind are mitigated, and shorter viewing distances are less visually demanding. If this selection bias is present, the observed association may reflect a consequence of pre-existing refractive error rather than a causal effect of the sporting environment. Several factors, however, support the plausibility of a genuine environmental effect:

- **Confounder Control:** The association remained statistically significant after adjusting for parental history of myopia, the strongest genetic confounder.
- **Epidemiological Consistency:** The magnitude of the association (AOR = 2.44) is comparable to the adjusted odds ratio of 1.79 reported by Zhang et al. (2022) in a larger Chinese cohort.
- **Biological Plausibility:** The light-dopamine mechanism is supported by robust experimental evidence from animal models and randomized controlled trials in pediatric populations (He et al., 2015; Wu et al., 2010).

Despite these supporting factors, the cross-sectional design of this study cannot definitively establish causality. Longitudinal cohorts tracking sporting environments and refractive status from childhood through young adulthood are required to resolve the directionality of this relationship.

5.5 Clinical and Public Health Implications

The present findings highlight several practical implications for both clinical practice and public health, particularly within the context of university athletes, a group that has received relatively limited attention in myopia prevention efforts.

First, vision screening protocols should be strengthened and standardized. Rather than relying on occasional or informal assessments, it would be beneficial to incorporate mandatory vision screening into the pre-participation physical evaluation (PPE) for all incoming athletes. Importantly, screening should extend beyond visual acuity to include objective refractive assessment, such as autorefraction, to improve diagnostic accuracy (Jacobs et al., 2023). The results of this study also support a risk-based approach: athletes with a family history of myopia or those primarily engaged in indoor sports may warrant closer monitoring and more frequent follow-up (Morgan et al., 2021).

Second, healthcare professionals working with student-athletes should take a more proactive role in counseling, particularly regarding modifiable behaviors. Increasing exposure to natural light is one such factor, as higher ambient light levels have been associated with retinal dopamine release, which may help regulate axial eye growth (Rose et al., 2008; Wu et al., 2010). In addition, adequate sleep should be emphasized as part of overall health promotion. Emerging evidence suggests that insufficient sleep may be linked to poorer ocular and visual outcomes, reinforcing the need to address sleep habits alongside academic and athletic demands (Ayaki et al., 2016).

At the institutional level, university athletic programs should integrate vision health into their broader health and wellness strategies. Coaches and athletic staff, who interact with athletes on a daily basis, are well positioned to reinforce preventive behaviors and identify individuals who may require further evaluation. From a public health perspective, these findings point to the need for more targeted interventions aimed at university-aged populations. Educational materials tailored to student-athletes, particularly those balancing intensive near work with indoor training, may help raise awareness and encourage protective behaviors (Holden et al., 2016). Overall, a coordinated approach that combines structured screening, behavioral counseling, and institutional support may contribute to reducing the risk and progression of myopia in this population.

These findings support the integration of vision health into university athlete health programs. Annual vision screening using visual acuity assessment and objective refraction may help identify athletes with uncorrected or under-corrected refractive error. Athletes with a family history of myopia and those participating primarily in indoor sports may benefit from closer monitoring. Counseling may also include

practical advice on healthy sleep habits and safe outdoor exposure, although future studies are needed to determine the optimal amount of outdoor time for university-aged athletes.

5.6 Other Factors

Years of athletic practice, daily training duration, and gender were not significantly associated with myopia after adjustment for other variables. These findings suggest that the amount of sports participation alone may be less important than the environment in which the sport is performed. However, these results should be interpreted cautiously because training duration was self-reported and total outdoor exposure was not measured.

6. Conclusion

This study found a high prevalence of myopia (51.60%) among amateur university athletes at Rangsit University, Thailand, a rate comparable to that of their non-athlete peers and substantially higher than that reported in European athletic populations. The findings highlight the multifactorial nature of myopia and identify three significant predictors. A positive family history is the strongest non-modifiable risk factor (AOR = 2.53; 95% CI: 1.25–5.12; $p = 0.010$), strongly reaffirming the foundational role of genetic predisposition. After adjustment, sport environment was also associated with myopia; participation in indoor sports was associated with more than double the odds of myopia compared with outdoor sports (AOR = 2.44; 95% CI: 1.14–5.23; $p = 0.021$).

In addition to these risk factors, this study identified a crucial and modifiable protective factor: sleeping more than six hours per day emerged as a significant behavior associated with a 63% reduction in the odds of having myopia (AOR = 0.37; 95% CI: 0.18–0.79; $p = 0.010$).

These results demonstrate that regular sports participation alone is insufficient to offset the myopia risk driven by genetic susceptibility and environmental influences, including lower outdoor light exposure associated with indoor sports. Therefore, we strongly recommend that vision screening protocols for student-athletes incorporate targeted assessments of family history and sport type. Furthermore, counseling on actionable lifestyle modifications that promote adequate sleep and intentional time outdoors beyond official training should be considered a standard of care. These combined strategies may provide crucial, additional protective benefits for this at-risk

population. Given the cross-sectional design of this study, these associations cannot establish causality, and the directionality of the indoor sport–myopia relationship warrants confirmation through prospective longitudinal studies. Future research should incorporate cycloplegic refraction, objective measurement of outdoor light exposure using wearable sensors, and longitudinal follow-up to track myopia progression and its determinants in this population.

7. Limitations

This study has several limitations. First, the cross-sectional design prevents causal inference and introduces the possibility of reverse causality, particularly for the association between indoor sport participation and myopia. Second, family history of myopia, sleep duration, and training characteristics were self-reported and may be affected by recall bias. Third, important confounders such as screen time, academic near work, total outdoor exposure, and academic workload were not measured. Fourth, refraction was performed without cycloplegia, which may have led to overestimation of myopia due to unrelaxed accommodation. Fifth, myopia was classified using the more myopic eye, which may yield a higher prevalence estimate than right-eye-only or mean-eye approaches. Sixth, no a priori sample-size calculation was conducted. Finally, because the sample was drawn from a single university, the findings may not be generalizable to all Thai university athletes.

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9. Abbreviations

Abbreviation	Full Term
AOR	Adjusted odds ratio
BCVA	Best-corrected visual acuity
CI	Confidence interval
COA	Certificate of approval
D	Diopter

Abbreviation	Full Term
df	Degrees of freedom
IMI	International Myopia Institute
IOC	Item-Objective Congruence
IQR	Interquartile range
OR	Odds ratio
PPE	Pre-participation physical evaluation
ROC	Receiver operating characteristic
SD	Standard deviation
SE	Spherical equivalent
SPSS	Statistical Package for the Social Sciences
VA	Visual acuity
VIF	Variance inflation factor

10. CRediT Statement

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