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RESEARCH

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Visual factors associated with physical activity in schoolchildren

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ABSTRACT

Clinical relevance: Physical activity is an essential part of childhood physical and mental development. Recent research identified visual problems associated with a sedentary lifestyle in children in Ireland.

Background: This study explored the association between visual function in children and their engagement with physical activities outside school.

Methods: Participants were 1,626 schoolchildren (728 aged 6–7-years, 898 aged 12–13-years) in randomly selected schools in Ireland. Before data collection, parents/legal guardians of participants completed a standardised questionnaire reporting physical activity as no activity (mostly on screens), light activity (occasional walking/cycling), moderate activity (<3 hrs/week engaged in sports), or regular activity (>3hrs/week engaged in sports). Measurements included logMAR monocular visual acuities (with spectacles and pinhole), in the distance (3 m) and near (40 cm), stereoacuity (TNO stereo-test), cover test, and cycloplegic autorefraction (1% cyclopentolate).

Results: Controlling for confounders (socioeconomic disadvantage and non-White ethnicity), linear regression analysis revealed presenting distance visual acuity, near visual acuity, and stereoacuity were significantly better amongst participants who reported regular physical activity rather than moderate, light or no activity in both 6–7-year-old and 12–13-year-old participants. Absence of clinically-significant refractive error (>−0.50D < 2.00D) was associated with regular physical activity. Participants presenting with visual impairment (better-eye vision <6/12) (odds ratio = 5.78 (2.72–12.29)), amblyopia (pinhole acuity ≤6/12 plus an amblyogenic factor) (odds ratio = 5.66 (2.33–13.76)), and participants at school without their spectacles (odds ratio = 2.20 (1.33–3.63)), were more likely to report no activity.

Conclusions: Children regularly engaged in physical activities, including sports; had better visual and stereoacuity; and were less likely to need spectacles. Visual impairment, amblyopia, and refractive error were associated with no physical activity. Spectacle wear compliance was associated with regular physical activity. Regular physical activity is an essential factor in childhood vision and addressing visual impairment in children is vital to increasing participation in sports and exercise. Socioeconomically disadvantaged and non-White communities would benefit most from these measures.

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Physical activity; refractive error; visual acuity; visual impairment

Introduction

Vision impairment (VI) is increasing globally due to ageing populations,[1] and increasingly myogenic lifestyles,[2] including sedentary living.[3] Physical inactivity accounts for 9% of worldwide premature mortality.[4] The Irish Children's Sport Participation and Physical Activity (CSPPA) study reported only 19% of children (10-12-year-olds) and 12% of adolescents (12-18-year-olds) achieve the recommended levels of physical activity for good health (60 minutes of moderate- to vigorous-intensity physical activity per day).[5] Worryingly, the likelihood of meeting the recommended physical activity levels decreases with age.[5] The World Health Organisation estimated the direct healthcare costs and lost economic output associated with physical inactivity at between €150–300 (AUD220–440) per citizen per year.[6] Physical activity in childhood is associated with health in adulthood. Hence, physical inactivity in children is considered one of the most urgent health concerns affecting society and policymakers internationally.[6]

In addition to vascular and neurological benefits, regular physical activity is associated with positive mental health, slower cognitive decline, reduced body fat and cancer prevalence.[7] Physical activity benefits the nervous and visual systems due to shared embryological origins.[8] Moreover, physical activity appears to offer a protective effect against myopia progression.[9] By contrast, lower physical activity levels are associated with earlier onset age-related macular degeneration, glaucoma, diabetic retinopathy,[8] depression and anxiety.[10] Adults with amblyopia avoid visually demanding sports due to issues anticipating moving targets.[11] Of further concern, visually impaired adults experience barriers to engaging in physical activities.[12] Likewise, visually impaired children and adolescents are less likely to engage in physical activity,[13] and sports.[14]

While regular engagement in sports and physical activities is critical for health and well-being, health gains from interventions targeting children lifestyles occur 40–50 years in the future.[7] Thus, effective policies targeting childhood

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physical inactivity, including reducing sedentary lifestyle behaviours, require an understanding of susceptible cohorts.

Recent research identified 'visual problems',[15] including myopia,[2] associated with decreased physical activity in children in Ireland. However, the association between specific aspects of visual function, level of visual acuity (VA) and physical activity engagement in schoolchildren in Ireland remain unknown. This study investigated the association between various aspects of visual function, including VA, stereoacuity, VI, amblyopia and uncorrected refractive error, with parent-reported hours of engagement in outside-school physical activity.

Methods

Sampling, recruitment protocols, participation rates, experimental techniques and methods employed are previously described in detail.[16] Stratified random sampling was used to obtain representative samples of children in mainstream schools in Ireland. Schools were stratified by primary/post-primary status, urban or rural living, and socioeconomic status. The Technological University Dublin Research Ethics Committee granted ethical approval, and the study adhered to the tenets of the Declaration of Helsinki.

Public involvement

During the design stage of the study, focus groups were engaged to assess the burden associated with and the time to complete the study questionnaire.[16] The study used parent/legal guardian reported measures as a proxy for engagement in physical activities outside school. Previous research found parental reports of physical activity aligned with objectively measured physical fitness.[17]

Data collection

Data were collected between June 2016 and January 2018. Participants were 1,626 schoolchildren in Ireland: 728 participants aged 6-7-years-old (377 boys and 351 girls) and 898 participants aged 12-13-years-old (504 boys and 394 girls). Ethnicity was as follows: White (combined: White 1346 participants) or non-White (combined: Black 80, East Asian 51, and South Asian 49).

Questionnaire

Parents/legal guardians of the participants completed a standardised eye health and lifestyle questionnaire reporting inter-alia, eye and vision problems, medical and previous eye examination, parental education and employment status. Completed questionnaires were returned to the first author in advance of data collection. The parents/legal guardians of participants reported the level of physical activity by answering the following question: 'Which of the following best describes your child's level of physical activity outside school? (Tick one box only):

(a) Spends all or most leisure time on phone/computer/TV (no activity).
(b) Spends time occasionally in light physical activities (e.g., walking, cycling), (light activity).
(c) Participates in regular sporting activities for up to 3 hours a week (e.g., football, swimming, gymnastics, basketball, etc.), (moderate activity).
(d) Participates in regular sporting activities for more than 3 hours a week (e.g., football, swimming, gymnastics, basketball, etc.), (regular activity)".

Hereafter referred to as no activity, light activity, moderate activity, and regular activity.

Assessed parental factors were paternal and maternal education level (first-level, second-level, third-level); and occupation (full-time paid work, part-time paid work, unemployed, looks after family full-time).

Examinations

Children with written informed consent from parents/legal guardians and child assent were examined on their school premises within school hours. The examination involved: Vision: monocular logMAR presenting (with spectacles if worn) VA were measured and scored by-letter with and without a pinhole at three metres and 40 cm. The TNO anaglyph stereo-test (Richmond products, South San Francisco, CA 94,080, USA) was used to quantify the degree of stereoacuity. Ocular alignment was evaluated using a cover-uncover test and an alternating cover test, using an accommodative target with and without spectacle correction (if worn) in the distance (3 m) and at near (40 cm).

Amplitude of accommodation was measured using a Royal Air Force rule, the push-up method. Cycloplegic autorefraction (Dong Yang Rekto ORK-11 Auto Ref-Keratometer) was performed at least 30 minutes post instillation of anaesthetic (Minims Proxymetacaine Hydrochloride 0.5% w/v, Bausch & Lomb, UK) and cycloplegic eye drops (Minims Cyclopentolate Hydrochloride 1% w/v, Bausch & Lomb, UK). The representative value for spherical equivalent refraction (SER) - sphere plus half the cylindrical value – was used in subsequent analysis.

Vision disorders were classified as follows: amblyopia (pinhole VA ≥ 0.3logMAR in the affected eye, plus the presence of an amblyogenic factor),[18] strabismus (misaligned eyes), significant refractive error (myopia SER≤−0.50 dioptre (D), hyperopia ≥2.00D, astigmatism ≥ 1.00D, anisometropia interocular difference SER ≥ 1.00D), and VI (presenting VA > 0.30logMAR in the "better eye'). Follow up: Subsequent to the examination, all parents/legal guardians received a detailed report advising them of the study findings and the necessity of any further treatment if required.

Statistical methodology

Data were analysed using statistical software package version 27 (IBM-SPSS Inc., Chicago, IL, USA). Categorical data are presented as a percentage, and continuous data are presented as the mean (standard deviation (SD)). Kolmogorov-Smirnov tests were performed to check data distribution. Logistic regression models were fitted to investigate the association and estimate the odds ratio (OR) and 95% CIs for sociodemographic and visual factors associated with physical activity. The primary outcomes examined were VA, stereoacuity, VI, amblyopia, and clinically significant refractive error by physical activity level.

Logistic regression analysis, with participants who reported 'no physical activity' as the reference category, was employed to examine the relationship of physical activity engagement with categorical variables while controlling for confounders. Presenting VA (logMAR) and stereoacuity (arc-seconds) were analysed as continuous variables in the multiple linear regression models. Amblyopia means amblyopia in either the right eye, left eye, or both. The 5% significance level has been used throughout, without correction for multiple tests.

Results

Statistical analysis of study questionnaires and examination results included 723 of the 728 6-7-year-olds (response-rate = 99.3%) and 887 of the 898 12-13-year-olds (response-rate = 98.8%). Parents/legal guardians reported 10.4% of 6-7-year-old and 14.4% of 12-13-year-old participants as 'no physical activity'; 30.3% of 6-7-year-olds and 14.3% of 12-13-year-olds as 'light physical activity'; 32.6% of 6-7-year-olds and 26.2% 12-13-year-olds as 'moderate physical activity' and 26.7% 6-7-year-olds and 45.1% of 12-13-year-olds as 'regular physical activity'.

Sociodemographic factors associated with physical activity

Sex (OR = 0.93, CI: 0.66–1.31, $p = 0.68$), urban or rural living (OR = 1.08, CI: 0.72–1.64, $p = 0.71$), and age-group (OR = 1.23, CI: 0.83–1.82, $p = 0.32$) were not associated with physical activity engagement; however, socioeconomic disadvantage (OR 6.76, CI 4.55–10.05, $p < 0.001$), and non-White ethnicity (OR = 8.05, CI 4.85–13.36, $p < 0.001$) were (Table 1). Unless otherwise stated, socioeconomic status and ethnicity are controlled for in all further analyses.

Parental factors

Regular physical activity engagement was positively associated with maternal education (third-level OR = 4.87, CI: 1.67–14.25, $p < 0.001$, second-level OR = 2.95, CI: 2.04–4.26, $p < 0.001$), and paternal education (third-level OR = 4.17, CI: 1.40–12.38, $p = 0.01$, and second-level OR = 2.98, CI: 2.02–4.39, $p < 0.001$); and maternal employment (full-time OR = 5.37, CI: 1.84–15.87, $p = 0.01$, and part-time OR = 7.38, CI: 2.48–21.99, $p < 0.001$), but not paternal employment ($p > 0.05$ across the employment categories) (Table S1).

Distance vision (3 m)

Distance presenting VA (better eye) was significantly better amongst participants who reported regular physical activity than participants who reported moderate, light or no physical activity 6-7-year-olds ($F_{3,720} = 5.02$, $p = 0.002$). Similar results were found for the 12-13-year-old ($F_{3,884} = 22.94$, $p < 0.001$) participants (Table 2 and Figure 1, where a higher value indicates poorer vision). Likewise, distance VA (worse eye) was significantly better amongst regular than moderate, light and no physical activity 6-7-year-olds ($F_{3,720} = 7.17$, $p < 0.001$) and 12-13-year-olds ($F_{3,884} = 18.88$, $p < 0.001$).

Near vision (40 cm)

Near presenting VA (better eye) was significantly better amongst participants who reported regular rather than moderate, light, or no physical-activity 6-7-year-olds ($F_{3,720} = 4.71$, $p = 0.003$) and 12-13-year-olds ($F_{3,884} = 3.85$, $p = 0.009$). Similar results were found for VA in the worse eye for 6-7-year-olds ($F_{3,720} = 4.71$, $p = 0.003$) and 12-13-year-olds ($F_{3,884} = 3.85$, $p = 0.009$) (Table 2).

Stereoacuity

Stereoacuity was significantly better amongst 6-7-year-olds who reported regular rather than moderate, light or no physical activity ($F_{3,720} = 5.01$, $p = 0.02$). Likewise, in 12-13-year-olds ($F_{3,884} = 8.66$, $p < 0.001$) (Table 2 and Figure 2, where a higher value indicates poorer stereoacuity). When stereoacuity was examined as a categorical variable (abnormal stereoacuity >240 arc seconds), regular engagement in physical activities outside school was associated with better stereoacuity <240 arc seconds in 6-7-year-olds (OR = 2.14 CI: 1.12–4.11, $p = 0.02$) and 12-13-year-olds (OR = 2.44, CI: 1.37–4.33, $p = 0.002$) (Table 3).

Hyperopia was associated with abnormal stereoacuity in both cohorts (6-7-years, OR = 3.00, 1.96–4.53, $p > 0.001$, 12-13-years OR = 10.53, 6.07–18.18, $p < 0.001$). Myopia was associated with abnormal stereoacuity in 12-13-year-olds (OR = 3.00, 1.96–4.53, $p > 0.001$), but not 6-7-year-olds ($p = 0.21$).

Amplitude of accommodation

There was no relationship between the amplitude of accommodation and physical activity engagement in 6-7-year-old ($F_{3,720} = 0.81$, $p = 0.49$) and 12-13-year-old ($F_{3,884} = 0.41$, $p = 0.75$) participants (Table 2).

Visual function, refractive error and physical activity engagement

Overall, 36.5% of participants were reported by their parents or legal guardians as engaging in regular sporting physical activities for more than three hours per week. This was lower amongst participants with amblyopia (18.1% vs 37.9%, $p < 0.001$) and VI (18.3% vs 37.5% $p < 0.001$). Table 3 displays the relationship between visual function, refractive error, and physical activity engagement in 6-7-year-old and 12-13-year-old participants.

Amblyopia was associated with no physical activity in 6-7-year-olds (OR = 6.44, CI: 1.92–21.62, $p = 0.002$) and 12-13-year-olds (OR = 5.28, CI: 2.00–13.92, $p < 0.001$). Amongst participants with a reported history of amblyopia treatment (n = 116), participants successfully treated for amblyopia (n = 78) were significantly (OR = 5.02, CI: 1.65–15.28, $p = 0.004$) more likely to be active than unsuccessfully treated amblyopic participants (n = 38) and non-treated amblyopic participants (n = 45) (Figure 3).

No physical activity engagement was associated with VI in 6-7-year-olds (OR = 4.11, CI: 1.13–15.00, $p < 0.001$) and 12-13-year-olds (OR = 6.90, CI: 2.72–17.49, $p < 0.001$), (Table 2).

Table 1. The relationship between engagement in physical activity stratified by age in 723 6-7-years-old and 887 12-13-years-old participants and socio-demographic factors.

Presenting vision†	No activity	Light activity	Moderate activity	Active	P-value
6–7 years (n = 723)	*N = 75*	*N = 219*	*N = 236*	*N = 193*	
Socioeconomic status					
Disadvantaged	46 (19.2)	101 (42.3)	59 (24.7)	33 (13.8)	**<0.001**
Advantaged	29 (6.0)	118 (24.4)	177 (36.6)	160 (33.1)	
Sex					
Male	41 (11.0)	98 (26.2)	116 (31.0)	119 (31.8)	**0.005**
Female	34 (9.7)	121 (34.7)	120 (34.4)	74 (21.2)	
Ethnicity					
White	48 (7.4)	192 (29.8)	221 (34.3)	184 (28.5)	**<0.001**
Non-white	27 (34.6)	27 (34.6)	15 (19.2)	9 (11.5)	
Living environment					
Urban	52 (14.3)	105 (28.9)	108 (29.8)	98 (27.0)	**0.004**
Rural	23 (6.4)	114 (31.7)	128 (35.6)	95 (26.4)	
Socioeconomic status					
Disadvantaged	46 (19.2)	101 (42.3)	59 (24.7)	33 (13.8)	**<0.001**
Advantaged	29 (6.0)	118 (24.4)	177 (36.6)	160 (33.1)	
Maternal education level					
First level	3 (12.0)	15 (60.0)	6 (24.0)	1 (4.0)	**<0.001**
Second level	29 (13.7)	89 (42.0)	51 (24.1)	43 (20.3)	
Third level	28 (6.6)	89 (21.0)	169 (39.9)	138 (32.5)	
Paternal education level					
First level	3 (11.5)	12 (46.2)	8 (30.8)	3 (11.5)	**<0.001**
Second level	22 (9.3)	82 (34.6)	87 (36.7)	46 (19.4)	
Third level	21 (6.3)	71 (21.4)	117 (35.2)	123 (37.0)	
Mother employment					
In fulltime paid work	17 (6.5)	69 (26.5)	96 (36.9)	78 (30.0)	**<0.001**
In part-time paid work	14 (8.1)	47 (27.2)	63 (36.4)	49 (28.3)	
Looks after the family fulltime	11 (18.3)	32 (53.3)	10 (16.7)	7 (11.7)	
Unemployed	19 (10.9)	51 (29.1)	56 (32.0)	49 (28.0)	
In fulltime education	4 (30.8)	4 (30.8)	2 (15.4)	3 (23.1)	
Father employment					
In fulltime paid work	28 (5.7)	116 (23.5)	192 (38.9)	158 (32.0)	**<0.001**
In part-time paid work	6 (14.6)	18 (43.9)	9 (22.0)	8 (19.5)	
Looks after the family fulltime	12 (24.5)	26 (53.1)	7 (14.3)	4 (8.2)	
Unemployed	5 (25.0)	9 (45.0)	5 (25.0)	1 (5.0)	
In fulltime education	1 (25.0)	1 (25.0)	0 (0.0)	2 (50.0)	
12–13 years (n = 887)	*N = 128*	**N = 127**	**N = 232**	**N = 400**	
Sex					
Male	78 (15.7)	64 (12.9)	121 (24.3)	234 (47.1)	0.15
Female	50 (12.8)	63 (16.2)	111 (28.5)	166 (42.6)	
Ethnicity					
White	89 (11.3)	109 (13.9)	204 (26.0)	383 (48.8)	**<0.001**
Non-white	39 (38.2)	18 (17.6)	28 (27.5)	17 (16.7)	
Living environment					
Urban	105 (14.1)	104 (14.0)	187 (25.1)	348 (46.8)	0.14
Rural	23 (16.1)	23 (16.1)	45 (31.5)	52 (36.4)	
Socioeconomic status					
Disadvantaged	36 (35.0)	25 (24.3)	21 (20.4)	21 (20.4)	**<0.001**
Advantaged	92 (11.7)	102 (13.0)	211 (26.9)	379 (48.9)	
Maternal education					
first level	4 (23.5)	5 (29.4)	2 (11.8)	6 (35.3)	**<0.001**
Second level	46 (20.1)	37 (16.2)	65 (28.4)	81 (35.4)	
Third level	58 (10.4)	73 (13.0)	148 (26.4)	281 (50.2)	
Paternal education					
First level	3 (17.6)	6 (35.3)	3 (17.6)	5 (29.4)	**<0.001**
Second level	46 (20.1)	44 (19.2)	58 (25.3)	81 (35.4)	
Third level	49 (9.7)	57 (11.3)	133 (26.3)	266 (52.7)	
Maternal employment					
In fulltime paid work	45 (13.6)	45 (13.6)	96 (29.1)	144 (43.6)	**<0.001**
In part-time paid work	23 (8.9)	28 (10.9)	74 (28.7)	133 (51.6)	
Unemployed	99 (29.0)	7 (22.6)	6 (19.4)	9 (29.0)	
Looks after the family fulltime	29 (14.8)	38 (19.4)	41 (20.9)	88 (44.9)	
In fulltime education	5 (45.5)	1 (9.1)	2 (18.2)	3 (27.3)	
Paternal employment					
In fulltime paid work	72 (10.9)	85 (12.9)	172 (26.1)	329 (50.0)	**<0.001**
In part-time paid work	14 (29.2)	12 (25.0)	6 (12.5)	16 (33.3)	
Unemployment	10 (28.6)	8 (22.9)	9 (25.7)	8 (22.9)	
Looks after the family fulltime	3 (15.8)	4 (21.1)	6 (31.6)	6 (31.6)	
In fulltime education	2 (50.0)	0 (0.0)	0 (0.0)	2 (50.0)	

Table 2. The relationship between engagement in physical activity stratified by age in 723 6-7-years-old and 887 12-13-years-old participants and presenting visual acuity (distance 3 m and near 40 cm), presenting stereoacuity, and amplitude of accommodation.

Presenting vision†	No activity	Light activity	Moderate activity	Active	P-value
6–7 years (n = 723)	*N = 75*	*N = 219*	*N = 236*	*N = 193*	
Visual Factors	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Worse eye Distance vision (logMAR)†	0.13 (0.04)	0.07 (0.02)	0.02 (0.01)	0.015 (0.01)	**<0.001**
Better eye Distance vision (logMAR)†	0.03 (0.02)	0.01 (0.01)	−0.022 (0.01)	−0.027 (0.01)	**0.002**
Near vision (logMAR)†	0.16 (0.04)	0.11 (0.02)	0.09 (0.01)	0.07 (0.01)	**0.016**
Stereoacuity (arc seconds)†	202.40 (29.33)	159.92(13.80)	129.60 (12.11)	138.34 (15.59)	0.051
Accommodation (Dioptres)†	13.01 (0.56)	13.83 (0.28)	13.68 (0.25)	13.76 (0.28)	0.49
12–13 years (n = 887)	*N = 128*	**N = 127**	**N = 232**	**N = 400**	
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Worse eye distance vision (logMAR)†	0.18 (0.03)	0.09 (0.03)	0.03 (0.02)	−0.02 (0.02)	**<0.001**
Better eye distance vision (logMAR)†	0.00 (0.02)	−0.10 (0.02)	−0.10 (0.01)	−0.14 (0.01)	**<0.001**
Near vision (logMAR)†	0.09 (0.02)	0.06 (0.02)	0.04 (0.01)	0.03 (0.01)	**0.002**
Stereoacuity (arc seconds)†	163.48 (23.13)	110.67 (17.84)	91.42 (10.47)	74.10 (6.97)	**<0.001**
Accommodation (D)†	12.02 ± 0.48	12.43 ± 0.30	12.03 ± 0.21	12.08 ± 0.15	0.75

†Measurements taken with participants spectacles if worn; Boldface indicates statistically significant $p < 0.05$; standard deviation (SD); Spherical Equivalent Refraction (SER); dioptre (D).

Strabismus was not associated with physical activity engagement in either age group (6-7-years: $p = 0.33$, 12-13-years, $p = 0.26$). Anisometropia was associated with no physical activity in 12-13-year-olds ($p = 0.006$) but not 6-7-year-olds ($p = 0.58$).

The absence of clinically significant refractive error (SER>-0.50D < 2.00D) was associated with regular physical activity in 6-7-year-olds (OR = 1.73, CI: 1.11–2.70, $p = 0.015$) and 12-13-year-olds (OR = 2.00, CI: 1.32–3.04, $p < 0.001$). By contrast, refractive errors (myopia: 6-7-year-olds, OR = 6.82, CI: 1.30–35.97, $p = 0.02$, 12-13-year-olds: OR = 3.13, CI: 1.89–5.15, $p <$ 0.001), and astigmatism, (6-7-year-olds: OR = 2.02, CI: 1.13–3.62, $p = 0.01$, 12-13-year-olds: OR = 2.22, CI: 1.44–3.42, $p <$ 0.001) were associated with no physical activity (Table 3).

Spectacle wear

Wearing spectacles was not associated with physical activity engagement in 6-7-year-olds ($p = 0.61$). Amongst 12-13-year-olds, there was no difference in physical activity level between participants wearing spectacles and those who did not need spectacles ($p = 0.32$). However, 12-13-year-old participants at school without their spectacles were significantly more likely to report no physical activity (OR = 2.27, CI: 1.26–4.12, $p = 0.007$) (Table 3).

Table 4 displays the odds ratio for visual factors associated with no physical activity engagement, controlling for confounders (socioeconomic disadvantage and non-White ethnicity).

Discussion

This study is the first to explore the relationship between eyesight and parent/legal guardian-reported hours of engagement in physical activities outside school in children attending mainstream schools in Ireland. The present study findings demonstrate children who have better VA, finer stereoacuity and do not need spectacles, are more likely to regularly engage in physical activity, including sports, than children who have reduced VA, reduced stereoacuity, and are in need of spectacles.

Overall, one in three participants reported engaging in physical activity outside school for over three hours per week. However, participants who reported no physical activity were significantly more likely to be visually impaired, aligning with previous research.[14] These findings are important as overall, one in ten participants reported no physical activity, yet this rose to one in three amongst visually impaired participants. Moreover, participants with amblyopia and refractive error spent less time engaged in physical activities outside school.

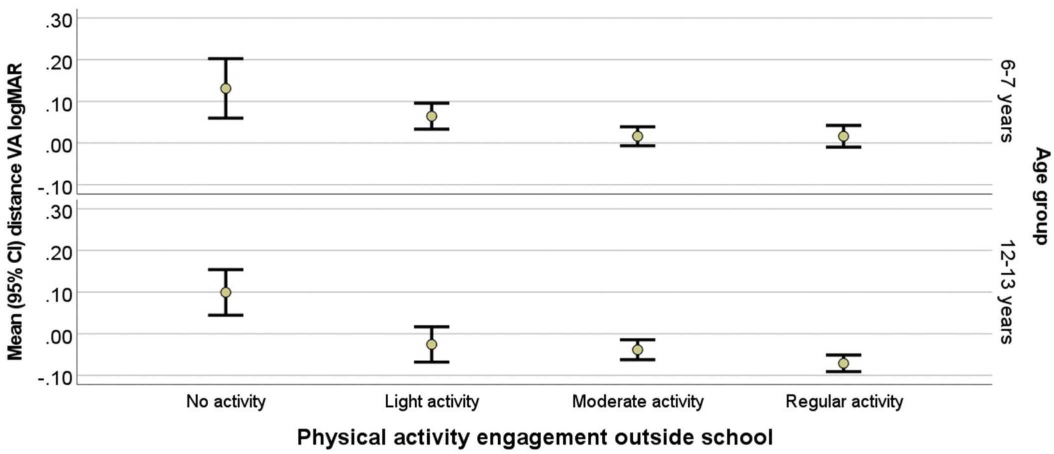

Figure 1. Mean logMAR distance vision in the better eye by physical activity category in 6-7-year-olds (top image) and 12-13-year-olds (bottom image). Higher logMAR acuity scores represent poorer vision.

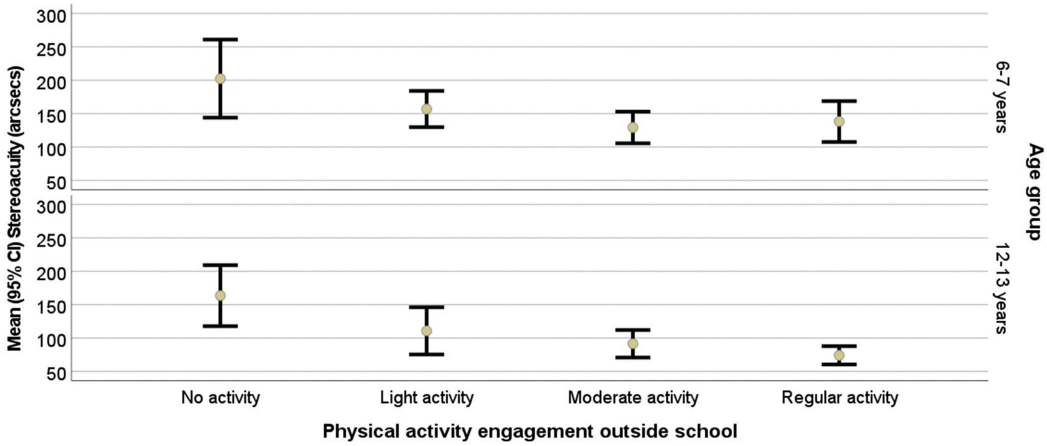

Figure 2. Mean stereoacuity by physical activity category in 6-7-year-olds (top image) and 12-13-year-olds (bottom image). A higher stereoacuity reading represents poorer stereoacuity.

In addition to the main findings, this study demonstrates parental/legal guardian level variables (education and employment) partly explain the inequality in physical activity levels. Aligning with the literature, physical inactivity was associated with socioeconomic disadvantage and ethnic minority status.[19] Moreover, parental/legal guardian educational level and occupation group were strong indicators of physical inactivity and VI in participants, demonstrating the importance of education. Lower parental educational levels and social class may indirectly affect physical activity levels by reducing exposure to sports, co-participation and transportation.[20]

The substantial costs associated with sports kit and coaching is another socioeconomic factor potentially limiting sports participation.[19] Fogelholm et al. established that the parent-child inactivity relationship was more potent than parent-child vigorous activity concluding parents wishing to modify the activity levels in their children may need to address their own.[21] Interestingly, the relationship between visual function and engagement in outside-school activities was significant despite controlling for sociodemographic factors in the present study.

The assessment of VA measures the ability to see detail, and this study found participants who regularly engaged in physical activities had excellent VA. Notably, the mean average VA (worse-eye) in physically active participants was better than 0.00 logMAR (6/6). This finding aligns with prior research where superior VA levels were found in Olympic-level athletes who participated in sports ranging from track and field to ice hockey, soccer, softball and speedskating.[22] Interestingly, Laby et al. found some differences in visual function; archers had superior VA (small stationary bullseye target) but poorer stereoacuity than soccer players, speedskaters, and softball players (dynamic sports involving larger targets and three-dimensional position awareness).[22]

In the present study, active participants who regularly engage in physical activities, including sports, had excellent stereoacuity (threshold level of depth perception), agreeing with prior research involving dynamic sports such as table tennis,[23] and soccer.[24] Stereoacuity enables a person to judge the relative position of objects in three-dimensional space. Stereoacuity is vital in dynamic sports involving a moving target, such as ball sports, where players must perform critically timed depth estimations.[24] Monocular cues such as lines and shadows facilitate depth awareness to a limited degree; however, binocular cues are superior due to subtle differences in images formed on the retina of the fellow eye.[24] However, the assessment of stereopsis using any static test cannot take into account the rapid changes in vergence required when a ball is moving towards a participant, and the measurement of near stereoacuity may not give a reliable measure of distance stereoacuity.[25] Despite the limitations associated with the TNO stereotest and other static stereotests, the TNO test is regularly used in optometric practice, and any near stereopsis deficit might be similar at distance viewing.[25]

In addition to good distance VA and near stereoacuity, physically active participants also had excellent near VA. While this is interesting, there is a paucity of literature addressing detailed visual functions for specific sports; hence, the mean level of VA required for specific sport remains largely unknown. The visual skills necessary for successful involvement in specific sports involve a detailed visual task analysis; hence, further research using specific outcome measures combining vision assessment and sports performance data is needed.[26]

Although the present study found no association between the amplitude of accommodation and physical activity; nevertheless, it should be noted that the push-up method employed in the present study may overestimate accommodation amplitude.[27] As exemplified by Jafarzadehpur, and Yarigholi,[28] where no difference in the amplitude of accommodation between table tennis champions and non-players was found, champion table tennis players nonetheless had a significantly enhanced accommodative facility. Hence, further analysis of accommodative function is required to understand the relationship between dynamic sports and dynamic accommodation response.

The absence of clinically significant refractive error was strongly associated with regular physical activity. Whereas no statistically significant relationship between hyperopia and physical activity/inactivity engagement was found. Conversely, myopia and astigmatism were significantly associated with no physical activity aligning with prior research involving Chinese 13-year-olds.[29] Similarly, Hansan et al.[30] reported low physical activity and excessive screentime related to myopia in Danish teenagers.

Table 3. The relationship between engagement in physical activity stratified by age in 723 6-7-years-old and 887 12-13-years-old participants and various aspects of visual function, (presenting visual impairment, amblyopia, refractive error and history of spectacle wear).

Presenting vision[†]	No activity	Light activity	Moderate activity	Active	P-value ǂ
6–7 years (n = 723)	*N = 75*	*N = 219*	*N = 236*	*N = 193*	
VI (better eye)[†]	N (%)	N (%)	N (%)	N (%)	
Yes	6 (8.0%)	8 (3.7%)	9 (3.8%)	4 (2.1%)	**0.007**
No	69 (92.0)	211 (96.3)	227 (96.2)	189 (97.9)	
VI (either eye)[†]					
Yes	14 (18.7%)	21 (9.6%)	17 (7.2%)	13 (6.7%)	**0.01**
No	61 (81.3)	198 (90.4)	219 (92.8)	180 (93.3)	
Amblyopia					
Yes	10 (13.3%)	15 (6.8%)	13 (5.5%)	5 (2.2%)	**<0.001**
No	65 (86.7)	204 (93.2)	223 (94.5)	188 (97.8)	
Abnormal stereoacuity (>240 arc seconds)[†]					
Yes	20 (26.7%)	39 (17.8%)	34 (14.4%)	28 (14.5%)	**0.02**
No	55 (73.3)	180 (82.2)	202 (85.6)	165 (85.5)	
Myopia (SER ≤− 0.50D)					
Yes	5 (25.0)	6 (30.0)	7 (35.0)	2 (10.0)	**0.03**
No	70 (10.0)	213 (30.3)	229 (32.6)	191 (27.2)	
Hyperopia (SER ≥ 2.00D)					
Yes	23 (10.4)	56 (25.2)	77 (34.7)	66 (29.7)	0.24
No	52 (10.4)	163 (32.5)	159 (31.7)	127 (25.3)	
Astigmatism (≥1D)					
Yes	27 (15.0)	63 (35.0)	48 (26.7)	42 (23.3)	**0.005**
No	48 (8.8)	156 (28.7)	188 (34.6)	151 (27.8)	
No significant refractive error(SER ≥− .50D ≤ 2.00D)					
Yes	55 (9.2)	180 (30.0%)	199 (33.1%)	167 (27.8%)	
No	20 (16.5%)	38 (31.4%)	37 (30.6%)	26 (21.5%)	**0.02**
Anisometropia					
Yes	9 (13.6)	16 (24.2)	24 (36.4)	167(25.8)	0.58
No	66 (10)	203 (20.9)	212 (32.3)	176 (26.8)	
Strabismus					
Yes	3(6.8)	13 (29.5)	14 (31.8)	14 (31.8)	0.79
No	72 (10.6)	206 (30.3)	222 (32.7)	179 (26.4)	
Spectacle wear					
No spectacles	60 (9.6)	188 (30.0)	210 (33.5)	169 (27.0)	
Wearing their spectacles	7 (11.1)	20 (31.7)	21 (33.3)	15 (23.8)	
At school without their spectacles	5 (17.9)	10 (35.7)	5 (17.9)	8 (28.6)	0.61
12–13 years (n = 887)	*N = 128*	**N = 127**	**N = 232**	**N = 400**	
VI (better eye)[†]	N (%)	N (%)	N (%)	N (%)	
Yes	14 (10.9)	5 (3.9)	4 (1.7)	7 (1.8)	**<0.001**
No	114 (89.1)	122 (96.1)	228 (98.3)	393 (98.3)	
VI (either eye)[†]					
Yes	26 (20.3)	12 (9.4)	16 (6.9)	21 (5.3)	**<0.001**
No	102 (79.7)	115 (90.6)	216 (93.1)	375 (94.8)	
Amblyopia					
Yes	12 (9.4)	11 (8.9)	7 (3.0)	10 (2.5)	**<0.001**
No	116 (90.6)	116 (91.3)	225 (97.0)	390 (97.5)	
Abnormal stereoacuity (>240 arcsecs)[†]					
Yes	23 (18.0)	19 (15.0)	26 (11.2)	33 (8.3)	**0.002**
No	105 (82.0)	108 (85.0)	206 (88.8)	367 (91.8)	
Myopia (SER ≤− 0.50D)					
Yes	35 (24.6)	29 (20.4)	35 (24.6)	43 (30.3)	**<0.001**
No	93 (12.5)	98 (13.2)	197 (26.4)	357 (47.9)	
Hyperopia (SER ≥ 2.00D)					
Yes	14 (13.9)	11 (10.9)	21 (20.8)	55 (54.5)	0.22
No	114 (14.5)	116 (14.8)	211 (26.8)	345 (43.9)	
Astigmatism (≥1.00D)					
Yes	47 (21.6)	40 (18.3)	48 (22.0)	83 (38.1)	**<0.001**
No	81 (12.1)	87 (13.0)	184 (27.5)	317 (47.4)	
No significant refractive error (SER >− .50D < 2.00D)					
Yes	80 (11.9)	90 (13.4)	179 (26.7%)	321 (47.9)	
No	48 (22.1)	37 (17.1)	53 (24.4)	79 (36.4)	**<0.001**
Anisometropia					
Yes	26 (26.0)	14 (14.0)	22 (22.0)	38 (38.0)	**0.006**
No	102 (13.0)	113 (14.4)	210 (26.7)	362 (46.0)	
Strabismus					
Yes	9 (24.3)	4 (10.8)	6 (16.2)	18 (48.6)	0.21
No	119 (14.0)	123 (14.5)	226 (26.6)	382 (44.9)	
Spectacle wear					
No spectacles	88 (13.2)	85 (12.7)	184 (27.5)	311 (46.6)	
Wearing their spectacles	19 (15.4)	26 (21.1)	31 (25.2)	47 (28.2)	
At school without their spectacles	21 (22.1)	16 (16.8)	17 (17.9)	41 (43.2)	**0.02**

[†]Measurements taken with participants spectacles if worn; ǂ Pearson Chi-squared analysis; Boldface indicates statistically significant $P < 0.0$; Spherical Equivalent Refraction (SER); dioptre (D); hours (hrs); Visual Impairment (VI).

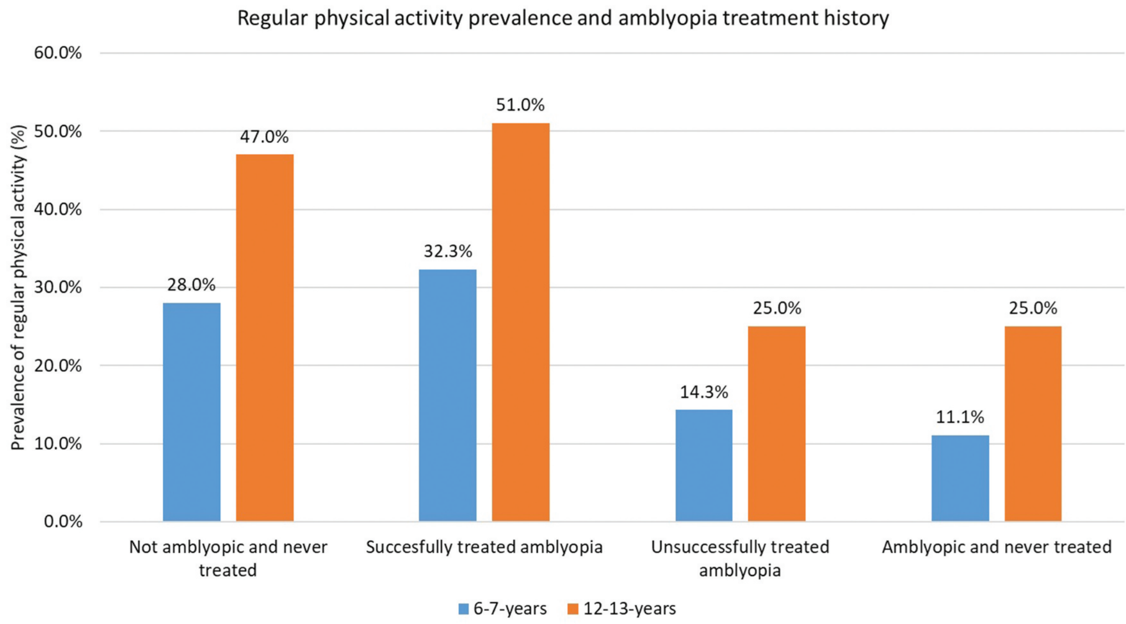

Figure 3. Prevalence of regular physical activity (>3 hrs/week) amongst 723 participants aged 6-7-year-old and 887 participants aged 12-13-year-old by amblyopia treatment history category: not amblyopic and no history of amblyopia treatment, previously amblyopic successfully treated for amblyopia, amblyopic and unsuccessfully treated, and amblyopic participants never treated.

Table 4. Odds ratio for visual factors associated with no physical activity controlling for confounders (socioeconomic status and ethnicity) in 1,610 participants (723 aged 6-7-years and 887 aged 12–13 years) in the Ireland Eye Study.

Variable	N (%)	Odds Ratio (95%CI)	P-value
Visual impairment (either eye)			
Yes	142 (8.7)	4.46 (2.64–7.52)	**<0.001**
No	1484 (91.3)	Ref	
Visual impairment (better eye)			
Yes	57 (3.5)	5.66 (2.33–13.76)	**<0.001**
No	1569 (96.5)		
Amblyopia			
Yes	83 (5.1)	5.78 (2.72–12.29)	**<0.001**
No	1543 (94.9)	Ref	
Myopia (≤− 0.50D)			
Yes	232 (14.3)	2.61(1.57–4.34)	<**0.001**
No	1349 (85.7)	Ref	
Hyperopia (≥2.00D)			
Yes	327 (20.1)	1.05 (0.68–1.62)	0.84
No	1299 (79.9)	Ref	
Astigmatism (≥1D)			
Yes	400 (24.6)	1.91 (1.32–2.77)	**<0.001**
No	1226 (75.4)	Ref	
Abnormal Stereoacuity (>240arcsecs)			
Yes	225 (13.8)	2.09 (1.32–3.30)	**0.002**
No	1401 (86.2)	Ref	
Strabismus			
Yes	82 (5.0)	0.76 (0.37-	0.45
No	1544 (95.0)	Ref	
Anisometropia (IOD ≥ 1D)			
Yes	169 (10.4)	2.94 (1.77–4.86)	**<0.001**
No	1457 (89.6)	Ref	
No significant refractive error(>−0.50–<2.00)			
Yes	1068 (65.7)	Ref	
No	558 (34.3)	1.57 (1.14–2.18)	**0.006**
Spectacle wear			
No spectacles	1315 (80.8)	Ref	
Wearing spectacles	187 (11.5)	1.44 (0.84–2.12)	0.23
At school without their spectacles	124 (7.6)	2.20 (1.33–3.63)	**0.002**

Dioptre (D); Visual impairment (VI); Interocular difference (IOD); Confidence intervals (CI); Reference category (Ref); Boldface indicates statistically significant $P < 0.05$.

In Ireland, prior research involving the same dataset reported that myopic 12-13-year-olds spend more time on screens, less outdoors, and less time engaged in physical activities than emmetropic 12-13-year-olds.[2] Furthermore, Zeri et al.[31] reported engagement in outdoor sports associated with lower levels of myopia. Hence, it may be time spent outdoors and less time on screens and not the physical activity itself offering a protective effect against myopia.[32] For example, Read et al.[32] found emmetropes spend significantly more time outdoors during daylight than myopes. Still, in contrast to the present study, they found no significant association with physical activity.[32] Hence, not being indoors engaged in near sedentary activities may be as important as being engaged in outdoor physical activities.[33] Longitudinal research employing objectively measured physical activity, light exposure and consistent and precise outcome measures is recommended.

There was no significant difference in physical activity level in the present study between participants wearing spectacles and those who did not. However, participants at school without their prescribed spectacles, as they were lost or damaged, were twice as likely to report no physical activity. Reasons for non-compliance with spectacle wear identified in the literature are socioeconomic disadvantage,[16] broken or lost spectacles, parental disapproval, and forgetfulness.[34] Nevertheless, when socioeconomic status and ethnicity were controlled for in the analysis, the significant relationship between physical inactivity and spectacle non-compliance persisted. Thus, in addition to early identification, diagnosis and treatment of refractive errors, healthcare education and strengthening vision care services are vital.

Recent research identified children with amblyopia had lower athletic competence (aiming and catching skills) than controls.[35] Similarly, in the present study, participants with amblyopia were almost six times more likely to report no physical activity than participants without amblyopia. Indeed, participants successfully treated for amblyopia were five times more likely to be regularly physically active than amblyopic participants. Binocular vision is essential for dynamic sports,[23] and amblyopic children will have very poor or no stereoacuity; hence, amblyopic participants are less likely to excel in some sporting activities. Moreover, amblyopic adults are more likely to avoid visually demanding sports due to issues catching a ball and balance.[11] However, physical activity improves brain plasticity.[36]

Also, visual (homoeostatic) plasticity can be boosted with physical exercise in amblyopic,[36] and non-amblyopic individuals.[37] Studies have repeatedly shown increased physical activity associated with reduced neuroinflammation.[38] For instance, neuro-inflammation affects brain structures, including the cortex (where visual information is processed), hippocampus (where sense is made of what is seen), brainstem (controls eye movements),[38] and thus, it stands to reason that physical inactivity may affect visual function. The present study highlights the positive impact and importance of addressing amblyopia, primarily preventable VI, before school onset when treatment is more likely to succeed,[39] to support health in later life.

In line with previous findings,[6] the present study found VI impacts physical activity engagement, which is concerning, as physical inactivity is associated with increased susceptibility to metabolic diseases and reduced high-level brain processing and function.[38] Reported fitness levels for visually impaired children are poorer than sighted children.[13] Understanding the hurdles and barriers to engaging in sports and physical activities visually impaired children encounter is vital. Consequently, children with VI are a critical target group when designing interventions to improve inclusion in sports and other physical activities.

The extensive range of variables and high participation rate in the Ireland Eye Study data set facilitates in-depth analysis of the relationship between physical activity engagement and visual function while examining the part sociodemographics play in this relationship. While visual function formed part of the examination, physical activity was measured via a questionnaire, which may inflate physical activity differences, underestimate the connection between eyesight and activity, or overestimate physical activity engagement.[21]

Future studies should include objective and exact measurements of time children spend in physical activities to verify the independent effect of time spent on sedentary or physical activity and the presence and magnitude of refractive error myopia and other visual factors. Although study findings are based on cross-sectional data, they are meaningful for childhood development as childhood physical activity habits track into adulthood.[40] Understanding the prevalence of physical activity and inactivity and identifying barriers to engaging in physical activity in children in Ireland will help guide public health policy.

Conclusions

Children who have better visual and stereoacuity and do not need spectacles, are more likely to regularly engage in physical activity, including sports, than children who have reduced visual acuity and stereoacuity, and are in need of spectacles. Visual impairment, amblyopia, astigmatism and myopia were associated with sedentary lifestyles. Socioeconomically disadvantaged and non-White children were particularly affected. The relationship between visual function and physical activity engagement may be bidirectional; it is hard to unravel whether physical inactivity results in reduced VA or reduced VA results in reduced physical activity engagement. Nevertheless, engaging in physical activities and reducing near sedentary activities are modifiable lifestyle changes that may prevent VI and refractive errors such as myopia. Eyecare clinicians should incorporate an assessment of physical activity engagement into consultations, include physical activity advice and plans in managing children's eyecare, and assess the benefits during follow-up.

Public health education programmes on increasing physical activity and reducing sedentary lifestyles are vital for schoolchildren and families. While investment in promoting and prescribing physical activity for all children is critical, policymakers should ensure socioeconomically disadvantaged, non-White and visually impaired children are further supported to participate in physical activity. Not only will the health benefits associated with physical activity manifest themselves in childhood but also in adulthood, where the benefits at that time will be material with significant benefits for not only the individual but also the community in terms of independence and quality of life.

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