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Association Between Motor Ability at 4½ years and Physical Activity at 10½ years in the Infant Aphakia Treatment Study

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Abstract

Association Between Motor Ability at 4½ years and Physical Activity at 10½ years in the Infant Aphakia Treatment Study

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The objective of this study is to understand the association between fine and gross motor skills and visual acuity and participation in physical activities among children treated for congenital cataracts at age 10 years. Data were analyzed by conducting crude and adjusted binary logit regression models to estimate odds ratios (OR) for the relationship between fine and gross motor skills (as measured by Movement Assessment Battery for Children-2 (MABC-2) scores) and visual acuity (VA) at age 10 ½ years and participation in organized and unstructured physical activity. There was no evidence to suggest fine and gross motor skills, as measured by MABC-2 scores at age 4 ½ years, predict participation in organized physical activity, but poorer fine and gross motor skills at age 4 ½ years were associated with reduced participation in unstructured physical activity. There was no significant association between VA in the treated eye at 10 ½ years and participation in organized or unstructured physical activities. Our findings suggest that poor fine and gross motor skills can have long-term implications for participation in physical activity in children treated for congenital cataracts. This study further emphasizes the importance of expanding research into the impact of unilateral visual conditions on development of motor skills and participation in physical activity.

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Background/Literature Review

Congenital cataract is an optical condition characterized by the presence of lens opacity at birth. It can affect either one or both eyes. It is one of the primary causes of treatable childhood blindness in the world and affects nearly 2 out of every 10,000 births in the US [1]. Unilateral congenital cataract, if not treated properly, has the potential to lead to poor visual outcomes. It must be treated early, during the first 6 to 12 weeks of life, to increase the possibility of restoring vision to the affected eye [2]. Congenital cataract is treated by performing a lensectomy where, put simply, the lens is removed and the child is left aphakic [3]. Following the surgery, it is essential to treat the child's aphakia through refractive correction, returning focusing power to the affected eye. Generally, there are two common options to treat this: implanting an intra-ocular lens (IOL) or utilizing a contact lens. Both treatments have benefits and complications, and although there is still an ongoing discussion among the scientific community about which is the preferred method of treatment, the contact lens has been found most beneficial [4].

Most children with unilateral congenital cataracts will suffer from deprivation amblyopia [3, 5]. Deprivation amblyopia resulting from unilateral congenital cataract occurs when, prior to surgery, there is only visual input from one eye so visual pathways have developed asymmetrically. Amblyopia, particularly unilateral congenital cataracts, can affect children's development of motor skills.

The Infant Aphakia Treatment Study (IATS) is a clinical trial evaluating the impact of choice of treatment for unilateral congenital cataracts on visual outcomes and risk of glaucoma. In the IATS population, nearly one-quarter had near-normal visual acuity (VA) in the treated eye, but approximately half had severe visual impairment in the treated eye [6-8]. In order to

achieve meaningful improvements in VA it is important for patients to strictly follow post-operative treatments, especially patching. Adherence to occlusion therapy was associated with better VA in the treated eye [9]. However, few of these children had any stereopsis [10] and none had high quality stereoacuity.

Although unilateral congenital cataract is a treatable condition and can be addressed early in a child's life, the implications on a child's health throughout his or her childhood have not been clearly documented or understood. More specifically, areas of interest are the health implications of ensuing conditions like poor VA, strabismus, and deprivation amblyopia. Studies have found an association of amblyopia with underdeveloped motor skills, slower reading speed, and feelings of low self-esteem [11-16]. One study found that children with amblyopia feel less scholastically, socially, and athletically competent [12]. They also perform worse in motor skills, as measured by the Movement Assessment Battery for Children (MABC) scores [12, 13, 17]. Amblyopic children have also been seen to score significantly lower in tasks requiring speed, dexterity and balance, providing further evidence for the amblyopia's impact on motor skill development [14, 15]. A potential mechanism for the poor development and performance of motor skills is thought to be the lack of stereopsis. In the IATS, gross stereopsis was present in 13% of the study population at age 4 ½ years and in half of the 27% of those with good VA in the treated eye [6]. However, none of the children developed high quality stereopsis. This lack of stereopsis may also be affecting these children's motor skill development.

Generally, children who do not participate actively in physical activities and exercise throughout development are at greater risk of chronic disease, such as cardiovascular disease (CVD) and obesity, in later life [18]. Concerns around underdeveloped fine and gross motor skills in children with visual impairments also lie in their potential impact on participation in

childhood physical activities. The evidence surrounding the directionality of this relationship, however, is conflicting. Weak yet positive correlations between motor skills and physical activity have been previously identified in cross-sectional and longitudinal studies, where motor skills predict children's involvement in physical activity [19-23]. In contrast, some longitudinal studies have found that motor skills did not significantly predict levels of physical activity [24, 25]. Research shows that visual impairments can further exacerbate these relationships and may serve as earlier predictors of low participation in physical activity [26-28]. Children with bilateral visual impairments specifically have been characterized with greater levels of adiposity and higher BMI [29, 30]. In addition, high levels of physical inactivity have been seen to carry on from adolescence to adulthood [31]. It is known that participation in exercise and physical activities can improve children's motor skills and physical development [25, 32-36], as well as reduce the risk for chronic diseases like CVD [18, 31]. Therefore, it is crucial to ensure visually impaired children get involved in physical activities throughout their development.

This study aims to further understand the association between fine and gross motor skills and VA and the participation in physical activities among children treated for congenital cataracts at age 10 years. Answering this question is important in order to know whether children treated for these and other visual impairments need additional encouragement to participate in physical activities, and in which periods of development, to stimulate motor skill development and potentially reduce the risk of greater adverse chronic health events.

Introduction

Unilateral visual impairments in children can have health implications beyond its effect on a child's vision. Evidence shows that children with unilateral visual impairments may have underdeveloped fine and gross motor skills as early as age 4 ½ years [17]. It is still unclear whether this delay in motor functioning affects children's level of participation in physical activities throughout childhood. Some studies which have considered the impact of fine and gross motor skills on physical activity have found that motor skills predict levels of physical activity [19-23], whereas other studies have not found this relationship [24, 25]. Nonetheless, it is known that children who lack participation in physical activity are at an increased risk of chronic diseases like obesity and CVD in later life [18]. Particularly, children with bilateral visual impairments have been characterized with greater levels of adiposity and higher BMI [29, 30]. Evidence supporting the health benefits of physical activity abound. Participation in exercise and physical activity in children can improve their motor skills and promote physical development [25, 32-36]. Most importantly, physical activity can reduce the risk of chronic disease and CVD [18, 31]. Consequently, understanding how unilateral visual impairments affect participation in physical activity is important in order to prevent these chronic conditions from worsening.

This study aims to further understand the association between fine and gross motor skills and VA and the participation in physical activities among children treated for congenital cataracts at age 10 years. Answering this question is important in order to know whether children treated for these and other visual impairments need additional encouragement to participate in physical activities, and in which periods of development, to stimulate motor skill development and potentially reduce the risk of greater adverse chronic health events.

Methods

The Infant Aphakia Treatment Study (IATS) was a multi-center randomized control trial comparing VA in children treated for unilateral congenital cataract before 7 months of age. Children were randomized to either receive an intraocular lens (IOL) at the time of cataract extraction or be left aphakic. The primary hypothesis of the study was that primary IOL implantation in an infant with a unilateral congenital cataract would result in a better visual outcome than leaving the eye aphakic and then optically correcting it with a contact lens. The study design, eligibility criteria, method of randomization, sample size determination, surgical techniques, patching and optical correction regimens, evaluation methods, and patient characteristics at baseline have been reported previously [7, 37-39]. This study was approved by the institutional review boards at all participating institutions and was in compliance with the Health Insurance Portability and Accountability Act. The off-label research use of the Acrysof SN60AT and MA60AC IOLs (Alcon Laboratories, Fort Worth, Texas) was covered by US Food and Drug Administration investigational device exemption #G020021. Written informed parental consent was obtained from all parents and written assent was obtained for all patients.

Fine and Gross Motor Skills

Fine and gross motor skills at age 4 ½ years were assessed with age band 1 of the Movement Assessment Battery for Children (MABC-2) [40]. The MABC-2, a norm-referenced performance test designed to evaluate gross and fine motor functioning in children aged 3 years to 16 years 11 months. The test comprises eight tasks assessing three domains and takes about 30 minutes to complete. Standard scores (mean 10, SD 3) are provided for individual tasks and for composite scores based on respondent age. The instrument has adequate test–retest reliability for

composite scores and for most tasks for age band 1 [41]. The validity of the MABC-2 is supported by its relationship with other broad-based movement tests, and by confirmatory factor analyses [42]. Travelling testers completed training in MABC-2 administration before data collection, and the IATS vision scientist (secondary tester) accompanied the traveling tester to the first visit at 4 years 6 months at each site to ensure that the testing environment was adequate and consistent with test developer recommendations. MABC-2 scores were categorized into two groups: scores greater than 15th percentile and less than 15th percentile. The 15th percentile cutoff was determined to be clinically relevant for MABC-2 scores [40], where scores greater than 15th percentile represent no significant motor difficulty and scores less than 15th percentile suggest careful monitoring and significant motor difficulty for lower scores [40].

Visual Acuity

Monocular optotype acuity in the treated eye for patients from IATS was measured and recorded on the logMAR scale at age and 10 ½ years utilizing the E-ETDRS testing protocols [43]. Patients were tested wearing their best correction. Monocular VA was tested first in the aphakic/pseudophakic eye. The eye not being tested was occluded using a translucent occluder to minimize the amplitude of latent nystagmus under monocular conditions. The initial testing distance was 3 meters (m). Distance was decreased to 1 m if the child was unable to see 20/800 letters. If the child still could not identify the letters, E-ETDRS testing was stopped for that eye and proceeded to test for hand motion. If hand motion was not present, the eye was assessed for light perception or no light perception following standard protocols. More extensive descriptions of VA measurement methods have been previously reported [7, 8]. VA was categorized in three groups: no visual impairment (≤ 20/40), mild to moderate visual impairment (20/40 ≤ 20/200), and blindness/severe blindness (worse than 20/200), guided by the recommended clinically

relevant visual impairment definitions [44]. Given that without treatment, VA is universally poor in this population, the blindness/severe blindness group was utilized as the reference group in analyses to better see if improved VA also results improvements in participation in physical activity.

Participation in Physical Activities

Participation in organized physical activities and in unstructured physical activities was reported by caregivers in a self-administered questionnaire completed at the age 10 ½ year clinical visit using two questions: (1) How often does the child participate in organized physical activities? (2) How often does the child participate in unstructured physical activities? Answers ranged from 1 to 8, defined as (1) daily, (2) few times a week, (3) once a week, (4) few times a month, (5) once a month, (6) few times in the last four months, (7) once in the last four months, and (8) never. For the purposes of this analysis, both variables were dichotomized as participation at least once a month and less than once a month given the presence of a nadir at "once a month" in the distribution.

Statistical Analysis

For statistical analysis, data were analyzed by conducting crude and adjusted binary logit regression models to estimate odds ratios (OR) for the relationship between fine and gross motor skills (as measured by MABC-2 scores) and VA at age 10 ½ years and participation in organized and unstructured physical activity. Covariates that met a priori criteria, as supported by previous evidence, were controlled for in the adjusted models. These included sex, type of treatment, private insurance, and age at surgery. Age at surgery was defined as young if surgery was conducted in the first 49 days or old if otherwise.

Results

Study Population

There were 114 children enrolled in the study. The current analysis focuses on children who were followed at age 10 ½ years and included more than 95% of the children randomized to treatment (109 of 114). Two additional children were excluded from the current analysis because the caregiver did not complete questionnaire data. The characteristics of the study population are presented in Table 1. The study participants included 50 boys (46.7%) and 57 girls (53.3%). Overall, 66 of the participants (61.7%) reported having private insurance while the remaining 41 (38.3%) did not. For treatment, 54 (50.5%) were treated with an IOL and 53 (49.5%) were treated with contact lens. 47 of the participants (43.9%) had congenital cataracts surgery at less than 49 days and the remaining 60 (56.1%) were older than 49 days at surgery.

The data regarding MABC-2 scores is detailed in Table 2. For MABC-2 Balance, Manual Dexterity and Total scores, almost half of the participants were greater than and less than 15th percentile. In Aiming & Catching, a third of the participants scored greater than 15th percentile and a quarter scored less than the 15th percentile. VA at age 10 ½ years, as categorized in this study, is detailed in Table 2. For VA measured at 10 ½ years, 26 of the participants (24.3%) had VA < 20/40, 13 (12.2%) had VA 20/40 < 20/80, 22 (20.6%) had VA 20/80 < 20/200, and 46 (43%) had VA worse than 20/200.

Half of the study participants reported participating in organized physical activity “more than once a week” and half “less than once a week” (Figure 1). Overall, 50% report participating in organized physical activity between “once in the last four months” and “few times a week”. For participation in unstructured physical activities, half of the participants reported frequency of

participation as less than "few times a week" and half more. Overall, 50% of the population reported participation in unstructured physical activity between a "few times a month" and "few times a week" (Figure 2). We defined low participation in organized and unstructured physical activity as anything less than once a month, representing 37.5% and 10.4% of the population, respectively.

MABC-2 & Participation in Physical Activity

There was little evidence to suggest fine and gross motor skills, as measured by MABC-2 scores, predict low participation in organized physical activity (Table 3), although children with poor balance at age 4 ½ years tended to be somewhat less likely to participate in organized physical activities than children with better scores on the balance subtest. However, children with poor fine and gross motor skills at age 4 ½ years were more likely to have infrequent participation in unstructured physical activity. For example, after adjusting for covariates, children with MABC-2 Manual Dexterity scores below the 15th percentile were 5 times less likely to participate in unstructured physical activities at least once a month than children with better manual dexterity skills at age 4 ½ years (OR_{adj} = 5.23 (1.05, 26.07) p-value = 0.044). Similarly, the parents of children with poor fine and gross motor skills at 4 ½ years overall, measured as a total MABC-2 score below the 15th percentile, were nearly 8 times more likely to report participate in unstructured physical activity less than once a month (OR_{adj} = 7.95 (0.99, 74.53) p-value = 0.051). Although the risks of infrequent participation in unstructured physical activity were higher in those with poor balance and aiming and catching skills at age 4 ½, these associations were weaker and did not approach statistical significance (OR_{adj} = 1.74 (0.45, 6.65) p-value = 0.42 and OR_{adj} = 1.88 (0.50, 7.11) p-value = 0.35, respectively) (Table 3).

Visual Acuity & Participation in Physical Activity

There was no evidence that VA in the treated eye was associated with reported participation in organized or unstructured physical activities. However, on average, those children with near normal VA were about fifteen percent as likely to report participating in unstructured physical activity less than once per month as those with VA worse than 20/200 (OR_{adj} = 0.15 (0.013, 1.61) p-value = 0.12) and those with VA of 20/40 to 20/200 were about half as likely to report infrequently participating in unstructured physical activity (OR_{adj} = 0.49 (0.11, 2.10) p-value = 0.33). However, these estimates are imprecise (Table 3).

Discussion

The objective of this study was to assess factors affecting participation in physical activity at age 10 ½ years in a cohort of children born with unilateral congenital cataract. These children, and those with amblyopia from other causes, have been shown to have poor fine and gross motor skills [17]. Given the importance of physical activity and physical fitness on overall health outcomes, we felt that it was important to see if these deficits might impact participation in physical activity in school-aged children. We observed that poor fine and gross motor skills in preschool did predict poorer participation, particularly in unstructured physical activities. Similarly, there was a suggestion that poorer VA in the affected eye might affect participation in unstructured physical activities. On the other hand, participation in organized physical activities, such as teams, did not seem to be similarly affected, perhaps because caregivers have more control over the amount of time spent in this type of activity.

Our findings are in line with some studies that have sought to assess the relationship between motor skills in children and involvement in physical activity [24, 25]. Our results suggest some directionality where underdeveloped motor skills may predict low participation in physical activity. Additionally, low MABC-2 Manual Dexterity appeared to be the strongest predictor of low participation in unstructured physical activity. This is an interesting finding given another study which found that skills in manual dexterity are the most significantly affected in children with visual impairments [45]. Similarly, a longitudinal study by Lopes et al found that motor coordination in children, measured throughout the first 4 years of the study, was a significant predictor of physical activity in children aged 6-10 years [22]. The children with lower measured motor coordination had lower levels of physical activity over time. These

motor coordination measures assess similar motor skills as the MABC-2 Manual Dexterity subtest [40].

We observed that participation in unstructured physical activity was more affected by poor fine and gross motor skills than participation in organized physical activities. Specifically, the MABC-2 Manual Dexterity and Total scores were largely associated with participation in unstructured physical activity, although the latter measure was imprecise. A 2008 study by Williams et al also found that children with poorer motor skills were less active than children with better motor skills [21]. These results, however, were true for total locomotor skills, which aligns with our findings regarding the MABC-2 Total score. Why participation in unstructured physical activity may have been more affected by poor fine and gross motor skills is unclear. However, we speculate that it could be due to the nature of unstructured physical activity, as participation in it is, for the most part, borne from the child's choice.

VA at age 10 ½ years was not significantly associated with participation in either organized or unstructured physical activities. However, the results suggested that groups with worse VA may be more likely to have limited participation in unstructured physical activity. This trend was not as evident for organized physical activity. These findings align with the results from our models assessing fine and gross motor skills and participation in physical activity, where the strongest associations were found for unstructured physical activity. Our results also make sense given the current understanding that, as evidenced by other studies, children with lower VA spend more time in sedentary behaviors and participate less in physical activities compared to children without visual impairments [26].

Overall, our findings suggest that poor fine and gross motor skills can have long-term implications for participation in physical activity in children treated for congenital cataracts. Of

particular concern are skills related to manual dexterity. This lack of involvement in physical activity may put this population at an increased risk of other chronic diseases, such as obesity and cardiovascular disease, in later life [31, 46]. The benefits of physical activity in reducing risk or severity of cardiovascular disease and other chronic conditions have been well documented [18, 25, 32-36, 47]. It is then important to ensure children with these visual impairments adopt healthy levels of physical activity throughout childhood in order to reduce the risk of CVD and chronic disease in later life.

Strengths & Limitations

This study is strong in its unique longevity. To our knowledge, this is the only study assessing the impact of poor VA and fine and gross motor skills in participation in physical activity among children treated for congenital cataract over a 10 ½ year time-period. In addition, our study is characterized by good study sample follow-up. 95.6% of the total study population (109 of 114) were followed-up at age 10 ½ years. This helps limit the likelihood of selection bias resulting from inadequate follow-up.

Limitations of this study include its relatively small sample size. This resulted in imprecise measures, which do not fully allow us to ascertain the strength of associations. Furthermore, the distribution between those who had high and low participation, as defined in this study, was not as extreme for organized physical activity as it was for unstructured physical activity. This may be why we did not see much of an effect for organized physical activity. Another limitation was the absence of MABC-2 data for age 10 ½ years. VA data was collected for both age periods, but MABC-2 scores were not collected at this phase of the study. Fine and gross motor skills may change after 6 years and affect participation in physical activity differently. More importantly, our study lacked a comparison group of children with normal

vision, which could have helped solidify our assessment and further define additional risks accrued by this population. A last limitation of this study is how participation in physical activity was measured. The data were collected form questionnaires taken by the caregivers. Some caregivers may be more or less knowledgeable of a child's participation in physical activity, both organized and unstructured, and responses may not accurately represent the child's level involvement in physical activity. Additionally, what constitutes unstructured physical activity may be different for each caregiver, which could have affected how the questions were approached.

Future Directions

This study further emphasizes the importance of expanding research into the impact of unilateral visual conditions on fine and gross motor skills. This study only looked at fine and gross motor skills at age 4 ½ years. Future studies should aim to assess fine and gross motor skills among children with visual impairments at later childhood and their association with participation in physical activity. Other studies should also focus on the impact of unilateral optic conditions on self-esteem, self-perception, physical fitness and obesity. Provided children who grow up with this condition are not participating in adequate levels of physical activity, they may be at greater risk of developing obesity and associated chronic conditions, such as cardiovascular disease. This study makes the case that children with amblyopia or congenital cataract could benefit from special encouragement to participate in physical activity. Additional studies should look at what are time periods are most important to intervene in order to improve these children's motor skills and physical activity outcomes.

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Tables

Table 1. Characteristics of a cohort of children from the Infant Aphakia Treatment Study

	Eligible Participants (n=107)	
	No.	**%**
Sex		
Male	50	46.7
Female	57	53.3
Private Insurance		
Yes	66	61.7
No	41	38.3
Treatment		
Intra-Ocular Lens	54	50.5
Contact Lens	53	49.5
Age at Surgery		
Young (<49 days)	47	43.9
Old (≥49 days)	60	56.1

Table 1. Descriptive characteristics of the study population. 107 participants were included from a total of 114 of the Infant Aphakia Treatment Study.

Table 2. Descriptive Characteristics of Exposure Variables

	Eligible Participants (n=107)	
	No.	**%**
MABC Balance Score		
GT 15%	57	53.8
LT 15%	48	46.2
Missing	2	
MABC Manual Dexterity Score		
GT 15%	54	50.9
LT 15%	52	49.1
Missing	1	
MABC Aiming & Catching Score		
GT 15%	80	74.8
LT 15%	27	25.2
Missing	0	
MABC Total Score		
GT 15%	48	45.7
LT 15%	57	54.3
Missing	2	
Visual Acuity at 10 ½ years		
≤ 20/40	26	24.3
20/40 ≤ 20/200	35	32.7
> 20/200	46	43.0

Table 2. Descriptive characteristics of exposure variables for the study population.

Table 3. Binary Logit Models - Estimated Odds Ratios and 95% CI for Fine and Gross Motor Skills Adjusting for Sex, IOL, Private Insurance, and Age at Surgery

	Organized Physical Activities					Unstructured Physical Activities				
	Crude OR	Adjusted OR	95% CI		p-value	Crude OR	Adjusted OR	95% CI		p-value
MABC TOT	1.46	1.44	0.61	3.40	0.41	8.63	7.95	0.95	66.35	0.06
MABC BAL	1.77	1.99	0.84	4.70	0.12	1.81	1.74	0.45	6.65	0.42
MABC MD	0.95	1.01	0.43	2.36	0.99	5.34	5.23*	1.05	26.07	0.04
MABC AC	1.48	1.45	0.57	3.71	0.44	1.79	1.88	0.50	7.11	0.35

Table 3. Crude and adjusted odds ratios for the association between fine and gross motor skills and participation in physical activity. Low MABC-2 MD score was significantly associated with low participation in unstructured physical activity.
**p-value < 0.05*

Table 4. Binary Logit Models - Estimated Odds Ratios and 95% CI for Visual Acuity at 10 ½ years Adjusting for Sex, Treatment, Private Insurance, and Age at Surgery

	Organized Physical Activities					Unstructured Physical Activities				
	Crude OR	Adjusted OR	95% CI		p-value	Crude OR	Adjusted OR	95% CI		p-value
OR										
VA 10 ½ years										
≤ 20/40	0.59	1.20	0.35	4.10	0.77	0.23	0.15	0.01	1.61	0.12
20/40 ≤ 20/200	0.63	0.66	0.25	1.76	0.41	0.51	0.49	0.11	2.10	0.33
> 20/200	REF	REF	REF	REF	REF	REF	REF	REF	REF	REF

Table 4. Crude and adjusted odds ratios for the association between VA at age 10 ½ years and participation in physical activity. On average, children with better VA were less likely to infrequently participate in unstructured physical activity.
**p-value < 0.05*

Figures

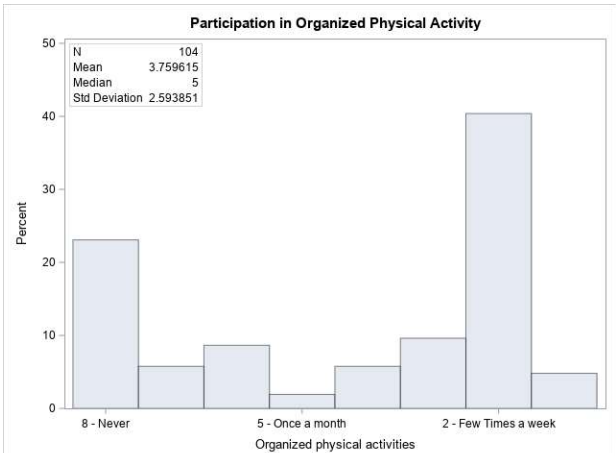

Figure 1. Distribution of participation in organized physical activity.

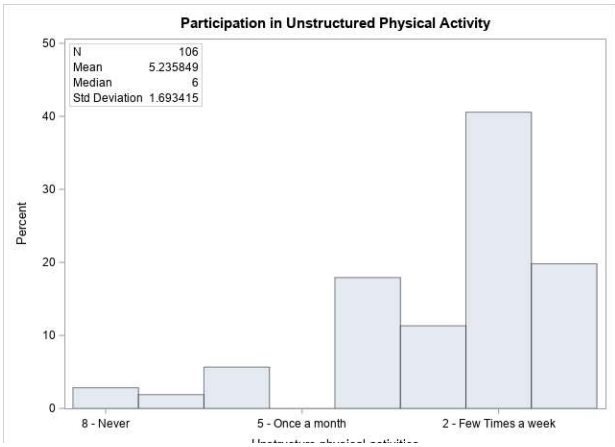

Figure 2. Distribution of participation in unstructured physical activity.

Appendix

Acronyms:

- CVD – cardiovascular disease
- IQR – interquartile range
- IOL – intra-ocular lens
- MABC – Movement Assessment Battery for Children
- OR – Odds Ratio
- SD – Standard Deviation
- VA = visual acuity