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ORIGINAL RESEARCH

Susceptibility to motion sickness in children from eight to eleven years of age

Suscetibilidade à cinetose em crianças de oito a onze anos

Susceptibilidad al cinetosis en niños de 8 a 12 años de edad

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ABSTRACT | Motion sickness is characterized by intolerance to movement, resulting from a sensory conflict between the visual, proprioceptive and vestibular systems. In the child population, motion sickness is frequent, but the difficult diagnosis ends up underestimating the prevalence in this specific group. Pediatric vestibular changes are of great importance in child development. The objective was to analyze the susceptibility to motion sickness in children and to verify possible associated factors, as well as to identify differences in the responses when compared to sex, age group and parents' self-perception. This is a cross-sectional study. The consecutive convenience sample consisted of children of both sexes, aged between eight and eleven years old. The *motion sickness questionnaire short form* (MSSQ) was applied individually with each child. Statistical analysis was performed using the SPSS Version v.21 (Chicago: SPSS). A significance level of 0,005 was adopted. *Kolmogorov-Smirnov*, *Student's T*, *Anova* and *Friedman's* were the statistical tests used. In total, 223 children were analyzed. 89.7% of the sample was susceptible to motion sickness. There was a significant difference in the comparison of susceptibility to motion sickness between genders, with girls being more susceptible, compared to boys (p=0.001). When comparing age groups, there was no statistical significance. Eleven-year-old children were more susceptible to motion sickness. There was a difference in the responses reported by children and parents about the children's susceptibility to motion sickness.

Keywords | Motion Sickness; Postural Balance; Children; Prevalence.

RESUMO | A cinetose se caracteriza pela intolerância ao movimento, resultante de um conflito sensorial entre os sistemas visual, proprioceptivo e vestibular. Na população infantil, a cinetose é frequente, porém o difícil diagnóstico acaba subestimando a prevalência nesse grupo específico. As alterações vestibulares pediátricas têm importante influência no desenvolvimento infantil. O objetivo do artigo foi analisar a suscetibilidade à cinetose em crianças e verificar possíveis fatores associados, bem como identificar diferenças entre as respostas, quando comparados os sexos, as faixas etárias e a autopercepção dos pais. Trata-se de um estudo transversal. A amostra de conveniência consecutiva foi constituída por crianças de ambos os sexos, com idade entre oito e onze anos. Para avaliar a suscetibilidade à cinetose, foi aplicado o motion sickness questionnaire short form (MSSQ), realizado individualmente com cada criança. A análise estatística foi realizada por meio do SPSS Versão v.21. Adotou-se nível de significância de 0,05. Utilizaram-se os testes estatísticos Kolmogorov-Smirnov; T de Student; Anova e teste de Friedman. Ao total, foram analisadas 223 crianças. Observou-se que 89,7% das crianças avaliadas eram suscetíveis à cinetose. Houve diferença significativa na comparação da suscetibilidade à cinetose entre os sexos, sendo as meninas, mais suscetíveis em relação aos meninos (p=0,001). Na comparação entre as faixas etárias, não houve significância estatística. Crianças com onze anos apresentaram maior suscetibilidade à cinetose. Houve diferença nas respostas relatadas pelas crianças e pais sobre a suscetibilidade das crianças à cinetose.

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Descritores | Enjoo devido ao Movimento; Equilibrio Postural; Crianças; Prevalência.

RESUMEN | El cinetosis es la intolerancia al movimiento pasivo, resultado de un conflicto sensorial entre los sistemas visual, propioceptivo y vestibular. La población infantil padece con frecuencia del cinetosis, pero su prevalencia se subestima debido al difícil diagnóstico en este grupo específico. Los trastornos vestibulares en niños influyen significativamente en su desarrollo. El objetivo de este artículo fue analizar la susceptibilidad al cinetosis en niños y sus factores asociados, así como identificar las diferencias entre las respuestas en la comparación entre los sexos, los grupos de edad y la autopercepción de los padres. Se trata de un estudio transversal. La muestra de conveniencia consecutiva estuvo compuesta de niños de ambos sexos, con edades comprendidas entre 8 y 12 años. Para evaluar la susceptibilidad al cinetosis, se aplicó el *motion sickness questionnaire short form* (MSSQ) de manera individual en cada niño. Para el análisis estadístico se utilizó el software SPSS, versión 21.0. El nivel de significancia adoptado fue de 0,05. Se utilizaron pruebas estadísticas de Kolmogorov-Smirnov; T de Student; Anova y test de Friedman. Participaron en total 223 niños. Se observó que el 89,7% de los niños evaluados eran susceptibles al cinetosis. Hubo una diferencia significativa en la comparación de la susceptibilidad al cinetosis entre los sexos, en la cual las niñas eran más susceptibles que los niños (p=0,001). En cuanto a los grupos de edad, no hubo significación estadística. Los niños de 12 años fueron más susceptibles al cinetosis. Hubo una diferencia en las respuestas informadas por los niños y los padres sobre la susceptibilidad de los niños al cinetosis.
Palabras clave | Mareo por Movimiento; Balance Postural; Niños; Prevalencia.

INTRODUCTION

Kinetosis, also known as motion sickness, is characterized by an intolerance to movement, given the sensory conflict between the visual, proprioceptive, and vestibular systems. For the most part, the set of symptoms associated with kinetosis, such as nausea, headache, sweating and vomiting, result from the stimuli of unhabitual movements. Means of transportation like automobiles, ships, trains, subways, and even elevators, may cause kinetosis.

Studies indicate that kinetosis is more frequent in children, setting in at around six or seven years of age, and reaching its peak at about 10 years of age[1-3]. According to a study, women are the most affected, and hormonal factors, such as menstruation and pregnancy, are possible aggravating factors[4]. The neurophysiological causes for the onset of kinetosis are still unknown. Hypotheses include: occurrence under sensory conflict; vestibular system immaturity (which may stabilize with age); hormonal influence (e.g., during menstruation or pregnancy), and habituation[1-4].

Though frequent, the prevalence of kinetosis in children is believed to be underestimated; which may be explained by difficulties in diagnosing vestibular changes in children[3,5]. Symptom identification is subjective, since it relies on self-observation and personal complaints. Since dizziness is often not seen as an abnormal symptom, affected individuals have trouble articulating their discomfort[5].

Moreover, parents may not recognize the disorder's symptoms, hampering the further clinical diagnoses[1,6]. If noted, symptoms are rarely attributed to vestibulopathies. The prevalence of vestibular dizziness in infants varies from 7.7 to 15%[6,7].

Clinically treating vestibular alterations is often deemed unnecessary. However clinical experience demonstrates that children, much like adults, can suffer these changes consequences in their daily lives, resulting in the cognitive impairment and social isolation which will directly and negatively affect their development[8,9].

We noticed, during the bibliographic review of the scientific literature, the scarcity of current studies on kinetosis in children. Though we were able find studies which broadly discussed vestibular alterations, and vestibular rehabilitation[2,8,9], our search found few studies on the prevalence of kinetosis in children[3,10-14].

We verified how important it is to identify the early symptoms of vestibular alterations, so as to avoid social isolation, learning disabilities and other possible consequences and aggravating factors. Considering the theme clinical relevance, this study aims to evaluate children's susceptibility to kinetosis, observe its probable variables; and identify response differences when genders, age groups and parents' self-observations are compared.

METHODOLOGY

This is a cross-sectional study. The non-probabilistic, consecutive sample was composed of children aged from 8 to 11 (i.e., from second to sixth grades), enrolled in

public schools in the metropolitan area of Porto Alegre. To achieve a standard effect size of 0.9, a sample of 192 individuals was calculated. The accepted significance level was 0.05 with a 90% power (EpiInfo – Statcal).

The study included children enrolled in the public school system, aged 8 to 11 who had neither hearing loss, nor underlying diseases that caused kinetosis-like symptoms, like sweating, nausea, and headache. Children who presented any physical or neurological impairment which would make applying the questionnaire impossible or who did not wish to participate were excluded.

The data were collected from August 2018 to September 2019. This research project was submitted to and approved by the chosen institutions, and the informed consent forms were signed by the children's parents or legal guardians.

This study evaluates susceptibility to kinetosis through the motion sickness questionnaire short form (MSSQ), developed by Reason and Brand[15], condensed and simplified by Golding[16], and translated into and adapted for Brazilian Portuguese by França and Branco-Barreiro[5]. Only the questions related to motion sickness in children (Motion Sickness A – MSA) were applied. Overall score was obtained by multiplying MSA scores by nine. The result was divided by nine minus the number of generators not used by the child, i.e.: (total score=MSA score×9)/(9–number of unused transports).

The instrument is composed of nine kinetosis-triggering environments and stimuli, including means of transportation and entertainment. They are: "cars," "buses or vans," "trains," "airplanes," "small boats," "ships or rafts," "playground swings," "merry-go-rounds," and "amusement park rides." There were five available response options: "never tried," "never got nauseous," "rarely got nauseous," "sometimes got nauseous," and "always got nauseous." The questionnaire score ranges from 0 to 3; 0 being "does not apply/never used" or "never got sick"; 1 "rarely get sick"; 2 "sometimes get sick"; and 3 "always get nauseous."

Descriptive data analysis was performed. The statistical significance of MSA distribution mean was assessed via the Kolmogorov-Smirnov test. In cases of normal distribution, Student's t- and ANOVA tests were used. In case of rejection of the normality hypothesis, the Friedman test was used. The value for rejecting the null hypothesis was $p<0.05$. All analyses were performed in SPSS v.21.

RESULTS

The studied sample, described in Table 1, consisted of 223 children, aged 8–11; of which 109 were females (48.9%) and 114 males (51.1%). The participants, from 2nd to 6th grades, are students from public elementary schools in the metropolitan area of Porto Alegre. Only 12.6% of the sample complained of loss of balance and/or learning difficulties. The participants' mean age was 9.14 (±1.02), MSA total mean score was 7.42 (±5.91).

Table 1. *Sample description* Porto Alegre, 2019. (n=223)

Characteristic	n (%)
Gender	
Female	109 (48.9%)
Male	114 (51.1%)
Age	
8 years old	77 (34.5%)
9 years old	57 (25.6%)
10 years old	67 (30.0%)
11 years old	22 (9.9%)
Schooling level	
2nd grade	39 (17.5%)
3rd grade	73 (32.7%)
4th grade	76 (34.1%)
5th grade	30 (13.5%)
6th Grade	5 (2.2%)
Complaint	
No complaint	195 (87.4%)
Learning disabilities	14 (6.3%)
Balance problems	14 (6.3%)

N: Sample.

In total, 89.7% of children in the sample (i.e., 196 participants) showed susceptibility to kinetosis (MSA). Only 27 children did not report any symptoms – receiving a score of zero; representing 12.1% of the sample.

As seen in Table 2, gender comparison presented statistical significance (p-value<0.001). Girls had a total mean score 2.73 (1.21; 4.26) times higher than boys.

Table 2. Difference of total MSA score means between genders. Porto Alegre, 2019 (n=223)

Average Female MSA	Average Male MSA	Difference of the Means	Confidence interval (95%)	p-value*
8.80	6.06	2.73	2,73 (1,21; 4,26)	<0.001

MSA: *Motion Sickness* A
Student's t-test

We obtained no statistical significance when comparing the age groups (Table 3), though there was an increase in the mean MSA score observed with aging.

Table 3. Comparison of age groups. Porto Alegre, 2019. (n=223)

Age	MSA Mean	Difference of the means	Confidence interval (95%)	P-value*
8-9 years old	8.43	1.27	(−1.42; 3.95)	0.613
8-10 years old	8.93	0.61	(−1.95; 3.18)	0.926
8-11 years old	8.67	0.47	(−3.24; 4.19%)	0.988
9-10 years old	9.54	−0.65	(−3,42; 2.12%)	0.929
9-11 years old	9,56	−0.79	(−4.65; 3.06%)	0.951
10-11 years old	10.25	−0.14	(−3.92; 3.63)	1.000

MSA: Motion Sickness A
*Analysis of Variance (Anova)

Table 4 shows the non-parametric analysis statistically significant difference (p=0.029) obtained when parental responses are compared to MSA results.

Table 4. Differences in MSA medians between parents and children. Porto Alegre, 2019. (n=23)

Children's MSA Median	Parents' MSA Median	Difference of the means	P-value*
4.00	3.00	1.00	0.029

MSA: Motion sickness A
*Friedman's test

DISCUSSION

Kinetosis is characterized by an intolerance to movement, mainly during vehicles locomotion, given the sensory conflict between sensorial, vestibule-visual, and vestibular systems[10-13]. Causing great discomfort, motion sickness affects individuals' quality of life. Despite kinetosis high prevalence in the world population, it is not yet regarded as a disease. In most cases, the individual endures its effects for years before seeking specialized care[3,17].

In total, 89.7% of children observed in this study were susceptible to motion sickness. A value close to another study with 76.3%[2]. Another study, also conducted with children, found a lower prevalence: 56%[18]. However, susceptibility to kinetosis is always more prevalent than absent. The aforementioned studies used the same protocol (MSSQ) to assess children's susceptibility to kinetosis.

Since this study prevalence is greater than what the literature reports, we elaborated a few hypotheses to explain our findings. The first relates to sample size. This study is significantly larger than our peers'; the second hypothesis relates to the schools teaching modalities. While our study evaluated children from public schools, a study done in São Paulo analyzed children from private schools[1]. Thus, sociocultural and economic differences may be a variable in the findings.

In this study, susceptibility to kinetosis was higher among girls (average=8.8) than in boys (average=6.06), with statistical significance (p<0.001). A study that employed the same evaluation protocol found similar data, identifying greater susceptibility to kinetosis in girls, though without any statistical significance, and with lower averages than our study[3]. Another study[19] also found statistically significant differences between genders, in which girls scored higher MSAs than boys.

Studies claim that gender and age are two significant variables in evaluating susceptibility to kinetosis. Investigations in sea, land, and air transportations suggest women are more susceptible to motion sickness than men[1,14,20]. These findings corroborate the results found in this study, in which girls higher MSA scores are statistically significant.

The scientific literature states that susceptibility to kinetosis first appears at around 6 to 7 years of age and reaches its peak between ages 9 and 10[14,19]. The age factor is closely tied to susceptibility to kinetosis, being most common in 9- and 10-year old individuals. This study observed MSA means rise with age: 11-year old participants were the most susceptible to kinetosis, followed by 10- and 9-year old children[4,19].

We also chose to compare the answers children gave in our questionnaire to their parents' or guardians' perception of their susceptibility to kinetosis. We know of no study which attempted the same correlation. We speculate that the difficulty children have in reporting their symptoms – as well as parental non-identification of the signs – are some of the contributing factors to the difficulty and scarcity of vestibular diagnoses in the infant population.

When we compared the reported results from a subgroup comprised of 23 children and their parents, we obtained a statistically significant difference (p<0.029) between their answers. Children recounted experiencing more instances of kinetosis than their parents noticed them having. We believe that evaluating a larger subgroup is exceedingly relevant to study this theme and demographic. This subgroup consisted of 23 parents or guardians of children participating in the study, who answered the same questionnaire. When applying our protocol, we evaluated the adults' perception of their children's susceptibility to kinetosis.

While administering the protocol, evaluators observed (or noticed themselves) children's complaints of learning disabilities and balance problems. Studies indicate that vestibular alterations can impair motor development, hindering a child's environmental awareness, and language acquisition and development[21]. It also influences

schoolchildren's learning and communication skills, such as speech, reading, writing, spelling, and mathematical calculations[22].

Maintaining postural stability while reading may be a more complex task for children with vestibular alterations, since reading encompasses many skills, such as perception, eye movement, and linguistic and semantic notions[23,24]. Learning disabilities may be characterized as the interaction of a series of factors resulting in lower productivity in learning situations[25].

In this study, only a small sample of interviewees reported complaints and/or learning disabilities, rendering a specific analysis of this variable impossible. Nonetheless, the scientific literature provides significant information on the relation between balance and learning, and the implications for literacy acquisition and the development of oral and written language resultant of vestibular alterations. Studies that explore this theme and relate these variables are required.

The MSSQ questionnaire proved itself an efficient tool for the evaluation of children's susceptibility to kinetosis. Not only is it quick to administer and easily comprehended, but it has also been translated into Portuguese and adapted for the Brazilian culture. Therefore, we recommend the use of this protocol when conducting new research that addresses vestibular alterations in childhood.

CONCLUSION

Susceptibility to kinetosis was observed in 89.7% of the sample, with girls being more susceptible. Eleven-year-olds had higher MSA means. There were differences in the answers relayed by children and parents regarding the former's susceptibility to kinetosis.

Thus, health care providers should take a closer look at a child's equilibrium, given how vestibular alterations affect development of children. Speech therapy – and other health areas treating these issues – entail vestibular evaluation and the rehabilitation of children. We believe that children suffering from kinetosis may benefit greatly from the vestibular rehabilitation performed by speech, physical and rehabilitation therapy providers.

REFERENCES

1. Golding JF. Motion sickness susceptibility. Auton Neurosci. 2006;129:67-76. doi: 10.1016/j.autneu.2006.07.019.
2. Franco ES, Caetanelli EB. Vestibular evaluation in children without auditory and vestibular complaints, by means of computerized vectoelectrostagmography. Int Arch Otorhinolaryngol [Internet]. 2006 [cited 2021 Aug 13];10(1):46-54. Available from: https://bit.ly/37G2Vaq
3. França SR, Perez, MLVD, Scharlach RC, Branco-Barreiro FCA. Susceptibilidade à cinetose em escolares. RECES. 2015;7(2):47-50. doi: 10.17921/2176-9524.2015v7n2p47-50.
4. Golding JF, Kadzere PN, Gresty MA. Motion sickness susceptibility fluctuates through the menstrual cycle. Aviat Space Environ Med [Internet]. 2005 [cited 2021 Aug 13];76(10):970-3. Available from: https://bit.ly/3m0hRbK
5. França SR, Branco-Barreiro FCA. Susceptibilidade à cinetose no idoso com doença vestibular. RECES [Internet]. 2013 [cited 2021 Aug 13];5(1):30-5. Available from: https://bit.ly/37FrMet
6. Said TS. Prevalência de queixas de sintomas vestibulares em crianças [dissertation on the Internet]. São Paulo: Pontifícia Universidade Católica de São Paulo; 2012 [cited 2021 Aug 13]. Available from: https://bit.ly/3xEpXcg
7. Russell G, Abu-Arafeh I. Paroxysmal vertigo in children: an epidemiological study. Int J Pediatr Otorhinolaryngol, 1999;49(Suppl 1):S105-7. doi: 10.1016/s0165-5876(99)00143-3.
8. Bittar RSM, Pedalini MEB, Medeiros IRT, Bottino MA, Bento RF. Reabilitação vestibular na criança: estudo preliminar. Rev Bras Otorrinolaringol. 2002;68(4):496-9. doi: 10.1590/S0034-72992002000400007.
9. Silva BMP, Didoné DD, Sleifer P. Potencial evocado miogênico vestibular cervical em crianças e adolescentes sem queixas vestibulares. Audiol Commun Res. 2017;22:e1885. doi: 10.1590/2317-6431-2017-1885.
10. Lipson S, Wang A, Corcoran M, Zhou G, Brodsky JR. Severe motion sickness in infants and children. Eur J Paediatr Neurol. 2020;28:176-9. doi: 10.1016/j.ejpn.2020.06.010.
11. Huppert D, Grill E, Brandt T. Survey of motion sickness susceptibility in children and adolescents aged 3 months to 18 years. J Neurol. 2019;266(Suppl 1):65-73. doi: 10.1007/s00415-019-09333-w.
12. Zhang LL, Wang JQ, Qi RR, Pan LL, Li M, Cai YL. Motion Sickness: Current Knowledge and Recent Advance. CNS Neurosci Ther. 2016;22(1):15-24. doi: 10.1111/cns.12468.
13. Takahashi M, Toriyabe I, Takei Y, Kanzaki J. Study on experimental motion sickness in children. Acta Otolaryngol. 1994;114(3):231-7. doi: 10.3109/00016489409126049.
14. Dobie T, McBride D, Dobie T Jr, May J. The effects of age and sex on susceptibility to motion sickness. Aviat Space Environ Med. 2001;72(1):13-20.
15. Reason JT, Brand JJ. Motion sickness. Oxford: Academic Press; 1975.
16. Golding JF. Predicting individual differences in motion sickness susceptibility by questionnaire. Pers Individ Dif. 2006;41(2):237-48. doi: 10.1016/j.paid.2006.01.012.
17. Mariotto LDF. Avaliação vestibular em adolescentes com cinetose [dissertation on the Internet]. Botucatu: Universidade Estadual Paulista; 2007 [cited 2021 Aug 13]. Available from: https://bit.ly/3iGkRrE

18. Chang CH, Pan WW, Tseng LY, Stoffregen, TA. Postural activity and motion sickness during video game play in children and adults. Exp Brain Res. 2012;217:299-309. doi: 10.1007/s00221-011-2993-4.

19. Henriques IF, Oliveira DWD, Oliveira-Ferreira F, Andrade PMO. Motion sickness prevalence in school children. Eur J Pediatr. 2014;173:1473-82. doi: 10.1007/s00431-014-2351-1.

20. Kennedy RS, Lanham DS, Massey CJ, Drexler JM, Lilienthal MG. Gender differences in simulator sickness incidence: implications for military virtual reality systems. Safe J. 1995;25(1):69-76.

21. Formigoni LG, Medeiros IRT, Santoro PP, Bittar RSM, Bottino MA. Avaliação clínica das vestibulopatias na infância. Braz J Otorhinolaryngol. 1999;65(1):78-82. doi: 10.1590/S0034-72992002000400007.

22. Franco ES, Panhoca I. Sintomas vestibulares em crianças com queixa de dificuldades escolares. Rev Soc Bras Fonoaudiol. 2008;13(4):362-8. doi: 10.1590/S1516-80342008000400011.

23. Legrand A, Bui-Quoc E, Doré-Mazars K, Lemoine C, Gérard CL, Bucci MP. Effect of a dual task on postural control in dyslexic children. PLoS One. 2012;7(4):e35301. doi: 10.1371/journal.pone.0035301.

24. Tomaz A, Ganança MM, Garcia AP, Kessler N, Caovilla HH. Controle postural de escolares com baixo rendimento escolar. Braz J Otorhinolaryngol. 2014;80(2):105-10. doi: 10.5935/18088694.20140024.

25. Rosa Neto F, Amaro KN, Prestes DB, Arab C. O esquema corporal de crianças com dificuldade de aprendizagem. Psicol Esc Educ. 2011;15(1):15-22. doi: 10.1590/S1413-85572011000100002.