

The Role of Motion Sensitivity and Headaches on Vestibular Rehabilitation Outcomes in Pediatric Vestibular Migraines

Adam S. Vesole, MD¹, Katheryn R. Bachmann, PhD², Gretchen A. Mueller, PT, DPT³, Violette H. Lavender, AuD², Micheal Castiglione, AuD², John H. Greinwald Jr., MD^{1,4}

1. Department of Otolaryngology-Head and Neck Surgery, University of Cincinnati College of Medicine, 2. Division of Audiology, Cincinnati Children's Hospital Medical Center, 3. Division of Occupational Therapy and Physical Therapy, Cincinnati Children's Hospital Medical Center, 4. Division of Pediatric Otolaryngology-Head and Neck Surgery, Cincinnati Children's Hospital Medical Center,



Introduction

- Vestibular migraine (VM) is one of the most common causes of vertigo in children (~30% of all vestibular and balance disorders).¹
- VM characteristics:** episodic vertigo associated with **severe headaches/migraines**, nausea, vomiting, photo/phonophobia, imbalance and **motion sensitivity (43-51%)**.²⁻⁵
- Pathophysiology:** increased motion sensitivity in VM patients theorized to be secondary to enhanced sensitization of central vestibular pathways from recurrent migraines.⁶
- VM Treatment:** primarily aims to control migraines. If continued vestibular symptoms despite migraine control, vestibular rehabilitation (VR) with physical therapy (PT) has been shown to be effective in adults.⁷ Conversely, it is unclear if VR is as effective in patients with uncontrolled headaches.
- MSQ:** Motion Sensitivity Quotient (MSQ) is a clinical assessment tool evaluating severity of motion sensitivity and used as a metric in VR to gauge outcomes in VM patients.

Hypotheses:

- Pediatric patients with **VM will demonstrate higher MSQ scores** compared to dizzy, non-VM counterparts and may serve as a diagnostic marker in differentiating VM from other childhood dizziness disorders.
- VM patients will have a more prolonged VR treatment course** with worse outcomes compared to non-VM patients.
- Within the VM cohort, we predict those with **higher MSQs and worse headache control will have a more protracted VR course** compared to those with lower MSQs and better-controlled headaches.

Methods

- Retrospective cohort analysis:** Pediatric patients from a single pediatric tertiary care center with a primary complaint of dizziness who completed audiometric and vestibular testing by audiologist and PT from Jan 2016 to Aug 2022.
- Interventions:** Audiogram and comprehensive vestibular testing (VNG, rotary chair testing, VEMPs, and vHIT). PT vestibular evaluation included MSQ.
- MSQ is a quantitative measurement of dizziness provoked from 16 different rapid changes in body and head position, calculated by the duration and severity of dizziness reported at each position. **MSQ is measured from 0 to 100% with mild motion sensitivity classified as 0-10%, moderate as 11-30%, and severe 31-100%.**
- Headache characteristics: measured headache/migraine frequency, severity, PedMIDAS (headache severity scale) and prophylactic migraine medication use.
- Outcome measures:** **Initial MSQ, number and duration of vestibular PT sessions, % of patients who met at least one PT session goal, post-treatment MSQ and MSQ decrease per PT visit.**
- Exclusions:** Prior intracranial or middle/inner ear surgeries (excluding tympanostomy tubes), age > 18 or if limited history did not allow for adequate diagnosis in either VM or non-VM groups.
- Statistical Analysis:** Two-sample t-tests with equal variances between combined VM and non-VM. Bonferroni multiple testing correction was applied as appropriate with t-testing. Cohen's effect size (d) was also utilized to determine clinical significance.

Figure 1

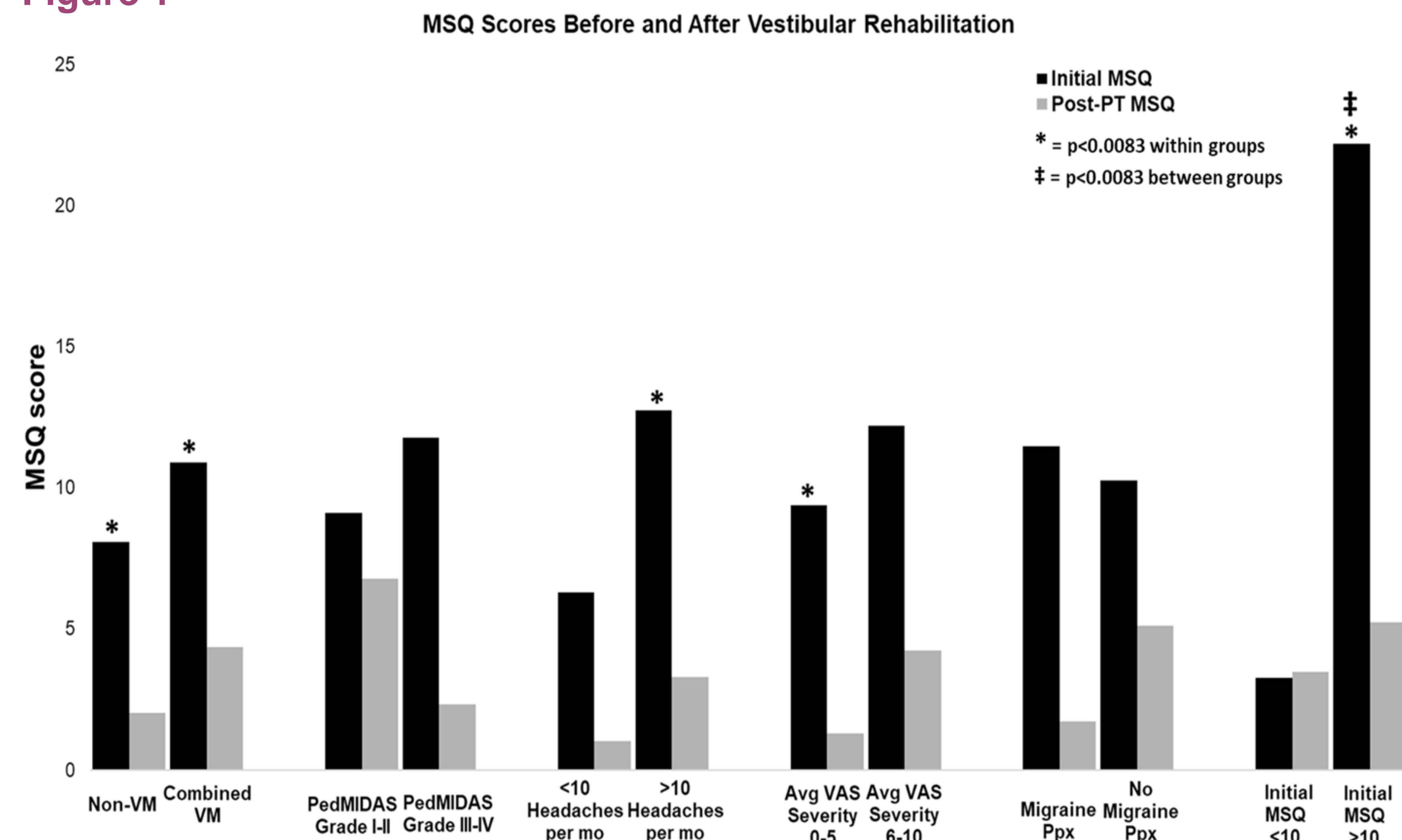


Table 1

Vestibular Rehabilitation Outcomes in VM versus non-VM Patients

VR Patients	VR Outcome Measures, Mean (SD)											
	Initial MSQ	p-value*	Post-PT MSQ	p-value*	No. of PT Visits	p-value*	Duration of PT Visits (mo.)	p-value*	Achieved at Least 1 PT Goal	p-value*	MSQ decrease per PT visit	p-value*
Non-VM	8.08 (13.1)		2.02 (8.6)	0.172	4.43 (3.2)	0.213	2.48 (2.3)	0.354	77% (42.5%)	0.016	1.84 (3.3)	0.423
Combined VM	10.89 (12.0)	0.081	4.35 (12.8)	0.172	4.91 (4.2)	0.213	2.89 (3.3)	0.354	60% (49.3%)	0.016	1.65 (2.9)	0.423
PedMIDAS Grade												
I-II	9.1 (7.6)	0.228	6.78 (17.1)	0.292	4.71 (3.4)	0.145	3.39 (4.0)	0.416	64% (49.7%)	0.456	1.08 (3.3)	0.484
III-IV	11.78 (9.3)		2.33 (5.2)		7.33 (8.0)		3.04 (3.7)		67% (50.0%)		1.46 (1.9)	
Headache Frequency												
<10 per mo	6.29 (8.4)	0.008	1.02 (2.8)	0.264	3.8 (3.0)	0.044	2.52 (3.2)	0.154	64% (49.0%)	0.320	1.36 (1.8)	0.114
>10 per mo	12.75 (11.5)		3.29 (11.0)		5.6 (5.0)		3.22 (3.6)		57% (50.1%)		2.03 (1.4)	
Avg VAS Severity												
0-5	9.39 (11.0)	0.170	1.31 (2.8)	0.222	5.36 (4.6)	0.350	3.53 (4.2)	0.101	64% (49.0%)	0.272	1.23 (1.7)	0.072
6-10	12.21 (10.8)		4.23 (13.3)		5.04 (4.9)		2.46 (2.4)		57% (50.4%)		2.6 (3.6)	
Migraine Prophylaxis												
Y	11.48 (13.3)	0.340	1.74 (3.9)	0.247	5.88 (5.8)	0.189	3.65 (3.6)	0.236	75% (44.7%)	0.101	2.17 (1.7)	0.356
N	10.25 (10.2)		5.13 (14.5)		4.69 (3.8)		2.76 (2.8)		56% (50.1%)		1.65 (3.1)	
Initial MSQ												
<10	3.27 (3.0)	<0.001	3.49 (12.2)	0.337	4.27 (3.2)	0.054	2.35 (2.7)	0.045	56% (50.3%)	0.171	0.41 (1.9)	<0.001
>10	22.19 (11.4)		5.25 (13.7)		5.87 (5.3)		3.7 (3.8)		67% (47.9%)		2.89 (3.1)	

Abbreviations: CI = confidence interval; combined VM = combined definite and probable vestibular migraine groups; mo. = months; MSQ = Motion Sensitivity Quotient; N = no; No. = number; non-VM = no vestibular migraine diagnosis; PedMIDAS = Pediatric Migraine Disability Assessment; SD = standard deviation; VAS = visual analogue scale; Y = yes

*Bolted, italicized p-values indicate statistical significance. P-value < 0.0083 is significant after Bonferroni correction.

References

- O'Reilly RC, Greywoode J, Morlet T, et al. Comprehensive Vestibular and Balance Testing in the Dizzy Pediatric Population. *Otolaryngol Neck Surg.* 2011;144(2):142-148. doi:10.1177/0194599810393679
- Henriques IF, Douglas de Oliveira DW, Oliveira-Ferreira F, Andrade PMO. Motion sickness prevalence in school children. *Eur J Pediatr.* 2014;173(11):1473-1482. doi:10.1007/s00431-014-2351-1
- Szirmai A. Vestibular disorders in patients with migraine. *Eur Arch Otorhinolaryngol.* 1997;254(1):S55-S57. doi:10.1007/BF02439724
- Langhagen T, Landgraf MN, Huppert D, Heinen F, Jahn K. Vestibular Migraine in Children and Adolescents. *Curr Pain Headache Rep.* 2016;20(12):67. doi:10.1007/s11916-016-0600-x
- Sharon JD, Hullar TE. Motion sensitivity and caloric responsiveness in vestibular migraine and Meniere's disease. *The Laryngoscope.* 2014;124(4):969-973. doi:10.1002/LARY.24285
- King S, Priesol AJ, Davidi SE, Merfeld DM, Ehtemam F, Lewis RF. Self-motion perception is sensitized in vestibular migraine: pathophysiologic and clinical implications. *Sci Rep.* 2019;9(1):14323. doi:10.1038/s41598-019-50803-y
- Whitney SL, Wrisley DM, Brown KE, Furman JM. Physical Therapy for Migraine-Related Vestibulopathy and Vestibular Dysfunction With History of Migraine. *The Laryngoscope.* 2000;110(9):1528-1534. doi:10.1097/00005537-200009000-00022

Results

Demographics

- 677 pediatric patients with dizziness presenting for audiologic and/or PT vestibular evaluation were initially reviewed.
- 257 patients met study inclusion criteria: 45.1% (n = 116) were classified with VM (27.6% definite VM and 17.5% probable VM) and 54.9% (n = 141) were non-VM. Of the 257 patients that had an initial PT vestibular evaluation with an MSQ score, 160 (62%) completed at least one subsequent VR treatment session.

Initial MSQ

- Initial mean MSQ was 9.1 (CI 95%: 6.6-11.6) in dVM patients, 9.9 (CI 95%: 6.3-13.4) in pVM, 9.4 (CI 95%: 7.4-11.4) in combined VM, and 7.8 (CI 95%: 5.7-9.9) in non-VM.
- There were no statistically significant (p>0.0125) differences in mean initial MSQs among pVM, dVM, combined VM and non-VM patients
- The initial MSQ trended higher in those with >10 headaches/migraines per month (10.8 vs. 6.2, p = 0.015) (Figure 1)

Vestibular Rehabilitation Outcomes

- Both combined VM and non-VM patients demonstrated significant improvement in MSQ after completing PT sessions (MSQ decreased 6.5, p = 0.004 for combined VM; 6.1, p = 0.004 for non-VM) (Figure 1).
- Only 60% of VM patients met at least one PT treatment goal while 77% in non-VM group met at least one PT treatment goal (small/medium effect-size, d= 0.37, p = 0.016).
- Both VM and non-VM patients with moderate/severe MSQs trended toward a longer duration of PT compared to patients with mild MSQs (VM: p = .045; non-VM: p = 0.010), though not significant (Table 1)
- VM patients with >10 headaches/migraine per month tended to attend more vestibular PT sessions on average than those with less frequent headaches (5.6 vs. 3.8, small/medium effect-size, d=0.44, p = 0.044).
- Headache severity, PedMIDAS, or use of prophylactic medication did not reveal any significant outcome differences between higher versus lower headache severity/disability groups or those on prophylactic medication.

Conclusions

- VR is an effective treatment for both VM and non-VM pediatric patients which has not been previously reported in the pediatric literature. MSQ decreased by 60% in VM and 75% in non-VM.
- MSQ by itself is not a reliable diagnostic marker for pediatric VM.
- VM patients, especially those with moderate-severe motion sensitivity (MSQ > 10) or poorly controlled headaches (>10 migraines per month) may be less responsive to VR and may require increased frequency and duration of VR.
- Our findings propose the importance of counseling pediatric patients with severe motion sensitivity or uncontrolled migraines regarding realistic expectations of their VR course.