The Journal of International Advanced Otology

J Int Adv Otol 2021; 17(4): 343-347 • DOI: 10.5152/iao.2021.8523

Original Article

Temporal Adjusters Can Reduce Pain During the Video Head Impulse Test for Patients With Mongoloid Facial Features, Without Increasing the Slippage-Induced Artifacts

Satoshi Takahashi[1], Takenori Miyashita[1], Ryuhei Inamoto[1], Yohei Ouchi[1], Shinjiro Fukuda[1], Izumi Koizuka[2], Hiroshi Hoshikawa[1]

[1]Department of Otolaryngology, Kagawa University, Kagawa, Japan
[2]Department of Otolaryngology, St. Marianna University School of Medicine, Kanagawa, Japan

ORCID IDs of the authors: S.T. 0000-0002-0069-4773; T.M. 0000-0002-6704-5620; R.I. 0000-0002-8841-5117; Y.O. 0000-0002-1513-3186; S.F. 0000-0001-7719-0592; I.K. 0000-0001-9651-9509; H.H. 0000-0002-2616-5044

Cite this article as: Takahashi S, Miyashita T, Inamoto R, et al. Temporal adjusters can reduce pain during the video head impulse test for patients with mongoloid facial features, without increasing the slippage-induced artifacts. *J Int Adv Otol.* 2021; 17(4): 343-347.

BACKGROUND: The aim of this study was to determine whether the extent and intensity of pain caused by wearing goggles during the video head impulse test (vHIT) could be reduced by adjusting the direction in which the band pulls the goggles, without increasing the number of artifacts recorded during vHIT.

METHODS: vHIT tests were performed in 65 healthy adult subjects, and the Visual Analog Scale (VAS) and Numerical Rating Scale (NRS) were used to evaluate pain intensity. Temporal adjusters were used to adjust the direction in which the band pulls the goggles, without decreasing the tightness of the temple straps. Artifacts were compared by calculating the instantaneous gains at 40 ms, 60 ms, and 80 ms of head movement.

RESULTS: Maximum VAS and NRS of pain were significantly reduced from 22.0 ± 2.3 to 13.0 ± 1.7 and from 3.0 ± 0.2 to 2.0 ± 0.2 (both $P < .0001$). The VAS score without adjusters was significantly correlated with the improvement of the VAS score with temporal adjusters ($P < .0001$, $r = 0.61$). The higher the VAS score without adjusters, the greater the improvement in the VAS score with temporal adjusters. The instantaneous gains were close to 1.0 under both conditions.

CONCLUSION: The pain induced by the goggle was significantly mitigated with temporal adjusters in the bilateral temple strap. Using temporal adjusters is a useful and easy solution to reduce discomfort during vHIT, while maintaining the tightness of the strap to decrease the slippage-induced artifacts.

KEYWORDS: Head impulse test, pain, artifacts, goggles

INTRODUCTION

The head impulse test (HIT) was first described in 1988 and is useful for diagnosing peripheral vestibular dysfunction.[1-3] This test is also essential when diagnosing stroke in the emergency room.[4] The presence of a normal HIT, direction-changing nystagmus in eccentric gaze, and skew deviation (vertical ocular misalignment) have 100% sensitivity and 96% specificity for stroke.[5] The video head impulse test (vHIT) includes high-speed video recording and quantitative head velocity measurements, which make it possible to quantitatively evaluate the gain in the vestibulo-ocular reflex (VOR) and catch-up (covert) saccades during head movement that cannot be detected with the naked eye.[1, 6-9] The vHIT is useful when evaluating patients with dizziness, with lateralization values determined by measuring the VOR in response to stimulation of the horizontal semicircular canal using high-speed video recordings and quantitative head velocity measurements.[1, 6-9]

Pain at the lateral orbital rims and slipping of the goggles are problematic in Asian subjects during vHIT, because the design of most vHIT devices is based on the facial features of Caucasians.[1] Typically, Asian persons have a Mongoloid facial structure, with a broader

Corresponding author: Satoshi Takahashi, e-mail: sato4-t@med.kagawa-u.ac.jp
Received: May 13, 2020 • **Accepted:** January 26, 2021
Available online at www.advancedotology.org

and flatter nasal dorsum and higher cheekbones than their Caucasian counterparts. Therefore, in Asian subjects, the goggles tend to flatten in the area of the nasal dorsum and exert intense pressure on the temples and lateral orbital rims.[1] Suh et al. reported that the number of slippage-induced artifacts was proportional to the tightness of the straps, and that a strap tightness of at least 45 cm H_2O was needed to minimize the slippage of the goggles.[1] The manufacturer of this device has not provided special mask pads for the vHIT ICS Impulse for commercial use in the Asian markets.

The objectives of this study were to determine whether the extent and intensity of pain caused by wearing goggles during the vHIT could be reduced by adjusting the direction in which the band pulls the goggles, without increasing the number of artifacts recorded during vHIT.

MATERIALS AND METHODS

The study protocol was approved by the institutional review board of the University Faculty of Medicine (H27-192) and conducted in accordance with the tenets of the Declaration of Helsinki. Informed consent was obtained from all study participants, and confidentiality was maintained according to the Guidelines for Protection of Human Subjects.

Sixty-five healthy adult Asian subjects (43 men, 22 women; mean age 24.6 ± 2.4 [range 22-33] years) were enrolled in the study. Hearing function was assessed in all subjects using pure-tone audiometry before the vHIT was performed. All subjects had normal hearing and vestibular function and denied any history of a cervical disorder.

Each subject was instructed to stare ahead at a stationary target at a distance of 1.5 m while the head was briefly rotated randomly around an earth-vertical axis from behind, as described elsewhere.[1,6] The eye and head movements were recorded and analyzed using the EyeSeeCam vHIT system (Interacoustics, Assens, Denmark). Temporal adjusters were used to adjust the direction in which the band pulls the goggles, without decreasing the tightness of the temple straps. The numbers of artifacts that occurred with and without placement of temporal adjusters in the temple straps were compared by calculating the instantaneous gains in VOR (eye/head velocity) at 40 ms, 60 ms, and 80 ms of head movement. Given that all the subjects were healthy with normal hearing, the gain in VOR was assumed to be 1.0. An artifact is indicated by an incorrect low gain at 40 ms and a high gain at 80 ms.[1]

The horizontal semicircular canal was evaluated and all vHIT tests were performed by the same otolaryngologist (ST). Pain intensity was evaluated using the scores on the VAS (0, none; 100, worst pain imaginable) and the NRS (0, none; 10, worst pain imaginable) at several anatomical locations (Figure 1).[10] before and after insertion of temporal adjusters in both temple straps (Figure 2A-C). Wine corks cut in half lengthwise were used as temporal adjusters (Figure 2D).

Statistical Analysis

The VAS and NRS pain scores are shown as the median ± standard error and the gain in VOR as the mean ± standard deviation (or as box plots in figures). The data were analyzed for statistical significance using the Wilcoxon signed-rank test and Pearson's correlation coefficient. All statistical analyses were performed using Statistical Packages for Social Sciences Version 25 (IBM Corp., Armonk, NY, USA). A *P*-value <.05 was considered statistically significant.

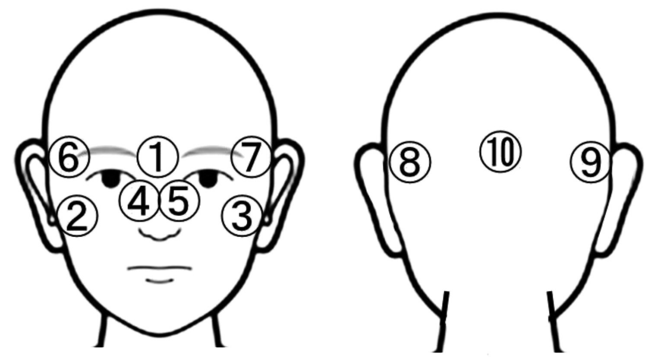

Figure 1. Areas in which goggle-induced pain was experienced, as reported in questionnaires. Points 2, 3, 6, and 7 indicate sites at the lateral orbital rims near the temple straps.

RESULTS

The maximum VAS and NRS pain scores were recorded at 11 anatomical locations. When temporal adjusters were inserted in both temples, the maximum VAS pain score decreased significantly, from 22.0 ± 2.3 to 13.0 ± 1.7, and the NRS pain score from 3.0 ± 0.2 to 2.0 ± 0.2 (both $P < .0001$; Figure 3A-C). The VAS score without adjusters was moderately correlated with the VAS score with temporal adjusters ($P < .0001$, $r = 0.50$; Figure 4A) and significantly correlated with improvement of the VAS score with temporal adjusters ($P < .0001$, $r = 0.61$; Figure 4B); in other words, the higher the VAS score without adjusters, the greater the improvement in the VAS score with temporal adjusters.

Without adjusters, points 2, 3, 6, and 7 at the lateral orbital rims near the temple straps (Figure 1) had higher VAS and NRS pain scores (see Supplemental Figure 1A and C); after insertion of temporal adjusters, the VAS and NRS scores improved at these sites (see Supplemental Figure 1B and D).

Bilateral insertion of temporal adjusters in the temple straps did not increase slippage-induced artifacts during the vHIT. The instantaneous gains in VOR at 40 ms, 60 ms, and 80 ms of head movement were calculated, to compare the number of artifacts with and without adjusters. The mean gains in VOR without and with temporal adjusters were 0.97 ± 0.16 and 1.00 ± 0.17 at 40 ms, 0.94 ± 0.11 and 0.95 ± 0.11 at 60 ms, and 0.90 ± 0.12 and 0.88 ± 0.12 at 80 ms, respectively (Table 1). The instantaneous gain in VOR was close to 1.0 at all anatomical sites under both conditions. The instantaneous gain in VOR with temporal adjusters tended to be higher at 40 ms and lower at 80 ms than that without adjuster (Table 1).

DISCUSSION

This study found that the insertion of temporal adjusters in both temple straps could adjust the direction in which the band pulls the goggles, without decreasing the tightness of the temple straps, and significantly reduced the pain induced by wearing goggles without increasing the number of artifacts caused by slipping of the goggles

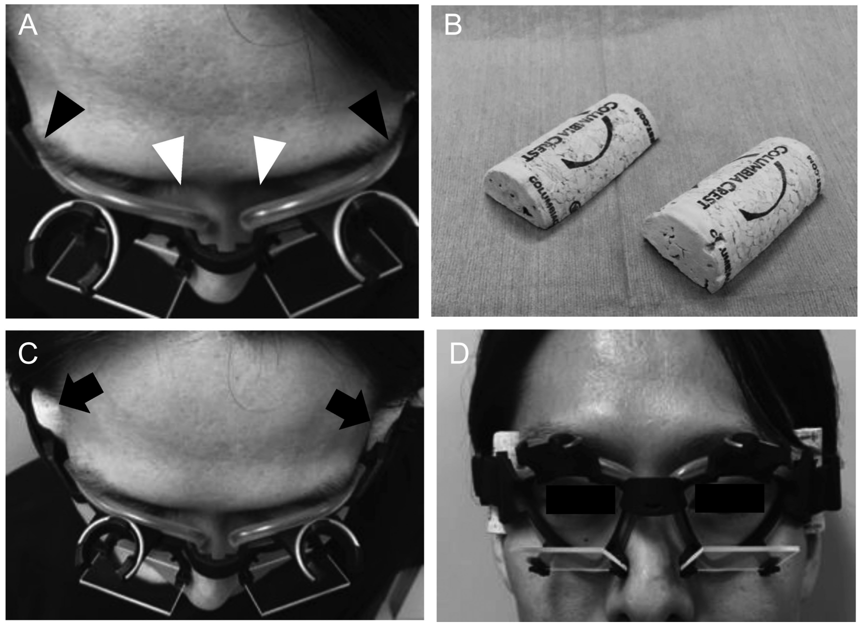

Figure 2. Fitting goggles with or without adjusters. (A) Goggles fitted without adjuster. The goggles are flat at the nasal dorsum (white arrowhead) and exert intense pressure on the temples and lateral orbital rims (black arrowhead). (B) Temporal adjusters made of wine corks cut in half lengthwise. (C, D) Goggles fitted with temporal adjusters inserted in both temple straps (black arrowhead).

during the vHIT. The VAS score without adjusters was significantly correlated with the improvement of the VAS score with temporal adjusters. The higher the VAS score without adjusters, the greater the improvement in the VAS score with temporal adjusters. Without temporal adjusters, several anatomical sites at the lateral orbital rims near the straps had higher VAS and NRS pain scores, and the pain was mitigated by the insertion of temporal adjusters. These findings suggest that the insertion of temporal adjusters in the temple straps is a solution to both goggle-induced pain and slippage-induced artifacts, especially in subjects who experience severe pain at the lateral orbital rims. Insertion of temporal adjusters in the temple straps is a convenient method of reducing discomfort while increasing the tightness of the temple straps, which may decrease slippage-induced artifacts.

As expected from the typical Asian facial structure, the VAS and NRS pain scores were higher at several sites on the lateral orbital rims near the temple straps when the vHIT goggles were worn. Adjusting the direction in which the band pulls the goggles using temporal adjusters improved the pain scores at these sites without reducing the tightness of the straps. Insertion of temporal adjusters could reduce the pain and discomfort caused by the goggles, and reduce artifacts

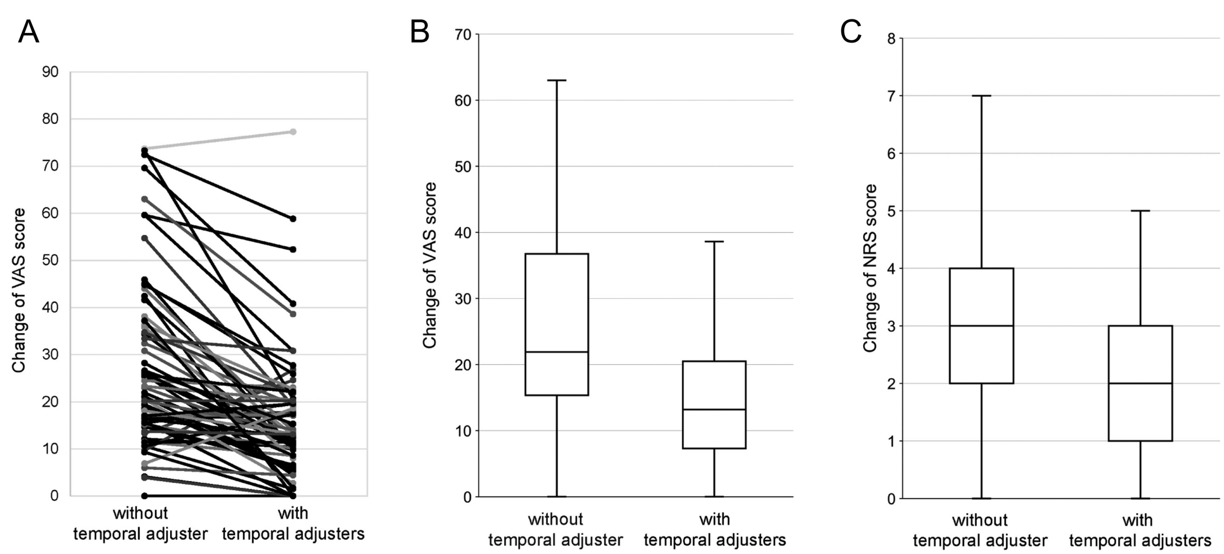

Figure 3. Change in maximum VAS and NRS pain scores with or without adjusters. (A) Change in maximum VAS pain scores in 65 subjects. (B) Box plots showing the change in maximum VAS pain score with and without adjusters. The data are shown as the median, middle 50% of the data, and the upper and lower extremes. The maximum VAS pain scores were significantly lower when temporal adjusters were inserted in both temple straps ($P < .0001$). (C) Box plots showing the change in maximum NRS pain score with and without adjusters. The maximum NRS pain scores were also significantly lower when temporal adjusters were inserted ($P < .0001$). VAS, Visual Analog Scale, NRS, Numerical Rating Scale.

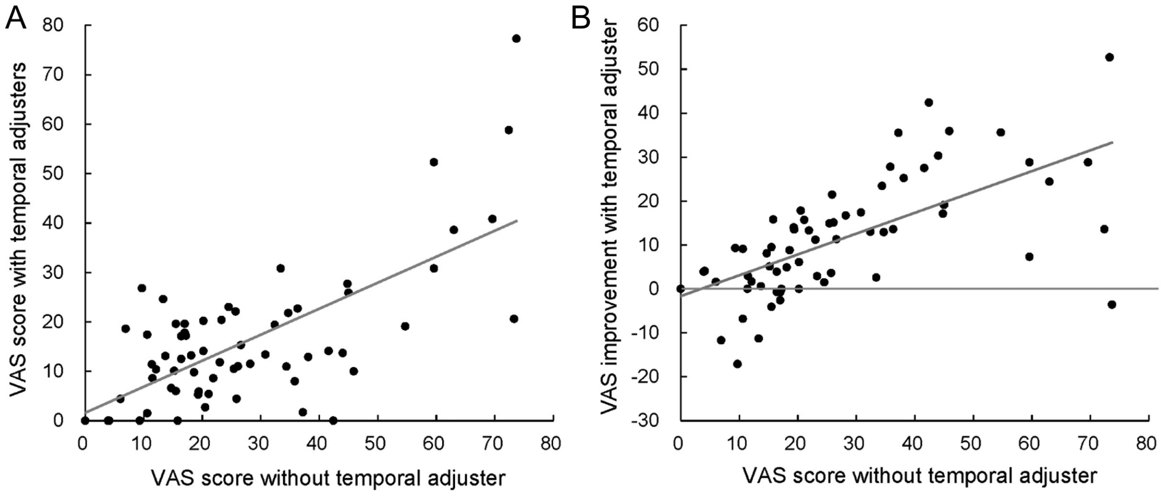

Figure 4. Correlation between the maximum VAS scores without adjusters and the improvement in the VAS with temporal adjusters, and the maximum VAS scores with temporal adjusters in 65 subjects. (A) The VAS score without adjusters was moderately correlated with the VAS score with temporal adjusters ($P < .0001$, $r = 0.50$). (B) The VAS score without adjusters was significantly correlated with the improvement in VAS score with temporal adjusters ($P < .0001$, $r = 0.61$). VAS, Visual Analog Scale.

Table 1. The Mean Instantaneous Gains in VOR at 40 ms, 60 ms, and 80 ms of Head Movement With and Without Adjusters in the Temple Straps

	40 ms	60 ms	80 ms
Without adjuster ($n = 30$)	0.97 ± 0.16	0.94 ± 0.11	0.90 ± 0.12
With adjuster ($n = 30$)	1.00 ± 0.17	0.95 ± 0.11	0.88 ± 0.12

by increasing the tightness of the straps. The wine corks used as temporal adjusters for the goggle straps in this study were ideal because cork has the advantages of a significant coefficient of friction, providing heat insulation, and being lightweight and moisture-resistant without risk of corrosion or deterioration.[11]

It has been reported that the tightness of the vHIT goggles is critical for the prevention of goggle slippage-induced artifacts, and that the decrease in the tightness of the goggles is directly proportional to the increase in the number of artifacts.[1,12,13] Artifact recordings are attributable to miscalculation of low gain at 40 ms, and a high gain calculation at 80 ms also indicates artifact.[1] To confirm that the insertion of the temporal adjusters did not increase artifacts, we evaluated the gains in VOR at 40 ms and 80 ms. In this study, instantaneous VOR gains with or without adjusters at 40 ms and 80 ms were close to 1.0 (0.88-1.00). None of the initial backward eye movement or acceleration and deceleration bumps were detected after insertion of the temporal adjusters in the temple straps (see Supplemental Figure 2Aand B). Furthermore, the insertion of temporal adjusters tended to increase the gain in VOR at 40 ms and reduce it at 80 ms. These results suggest that the insertion of temporal adjusters in the temple straps could reduce goggle slippage-induced artifacts by increasing the tightness of the straps. Goggles designed specifically for patients with Mongoloid facial features may be useful in reducing discomfort and google slippage-related artifacts on the vHIT.

Two limitations exist in this study. First, since a specific manufacturer's vHIT was used, the results do not necessarily apply to others. Further studies using other manufacturer's vHIT are needed to confirm whether the facial structure makes a difference in pain caused by goggles. Second, pain is subjective. The actual intervention with attention to potential pain may amplify the difference in the patient's report. Further research using a multi-point pressure sensor or other objective data might be of support in clarifying the evaluation of pain caused by the goggles.

CONCLUSION

The pain induced by wearing goggles during the vHIT was significantly decreased by adjusting the direction in which the band pulls the goggles, using temporal adjusters. The use of temporal adjusters was particularly beneficial for subjects who experienced intense pain at the temples and lateral orbital rims. Wine corks cut in half lengthwise were found to be ideal as adjusters for the vHIT goggle straps. The increased tightness of the straps achieved by the insertion of temporal adjusters could reduce the number of goggle slippage-induced artifacts on the vHIT in subjects with Mongoloid facial features.

Ethics Committee Approval: The study protocol was approved by the institutional review board of the University Faculty of Medicine (H27-192) and conducted in accordance with the tenets of the Declaration of Helsinki. Informed consent was obtained for all study participants, and confidentiality was maintained according to the Guidelines for Protection of Human Subjects.

Informed Consent: Verbal/Written informed consent was obtained from all participants who participated in this study.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept – T.M., I.K., H.H.; Design - S.T., T.M.; Supervision - T.M., S.F., I.K., H.H.; Resource - S.T., T.M.; Materials - S.T., R.I., Y.O.; Data Collection and/or Processing - S.T., R.I., Y.O.; Analysis and/or Interpretation - S.T., T.M.; Literature Search - S.T., T.M., I.K.; Writing - S.T., T.M.; Critical Reviews - T.M., S.F., I.K., H.H.

Acknowledgments: The authors thank Mayumi Tada for her technical support in this study. This work was supported by Scholarship Grant of Otolaryngology of Kagawa University Hospital.

Conflict of Interest: There are no conflicts of interest to disclose.

Financial Disclosure: This work was supported by Scholarship Grant of Otolaryngology of Kagawa University Hospital.

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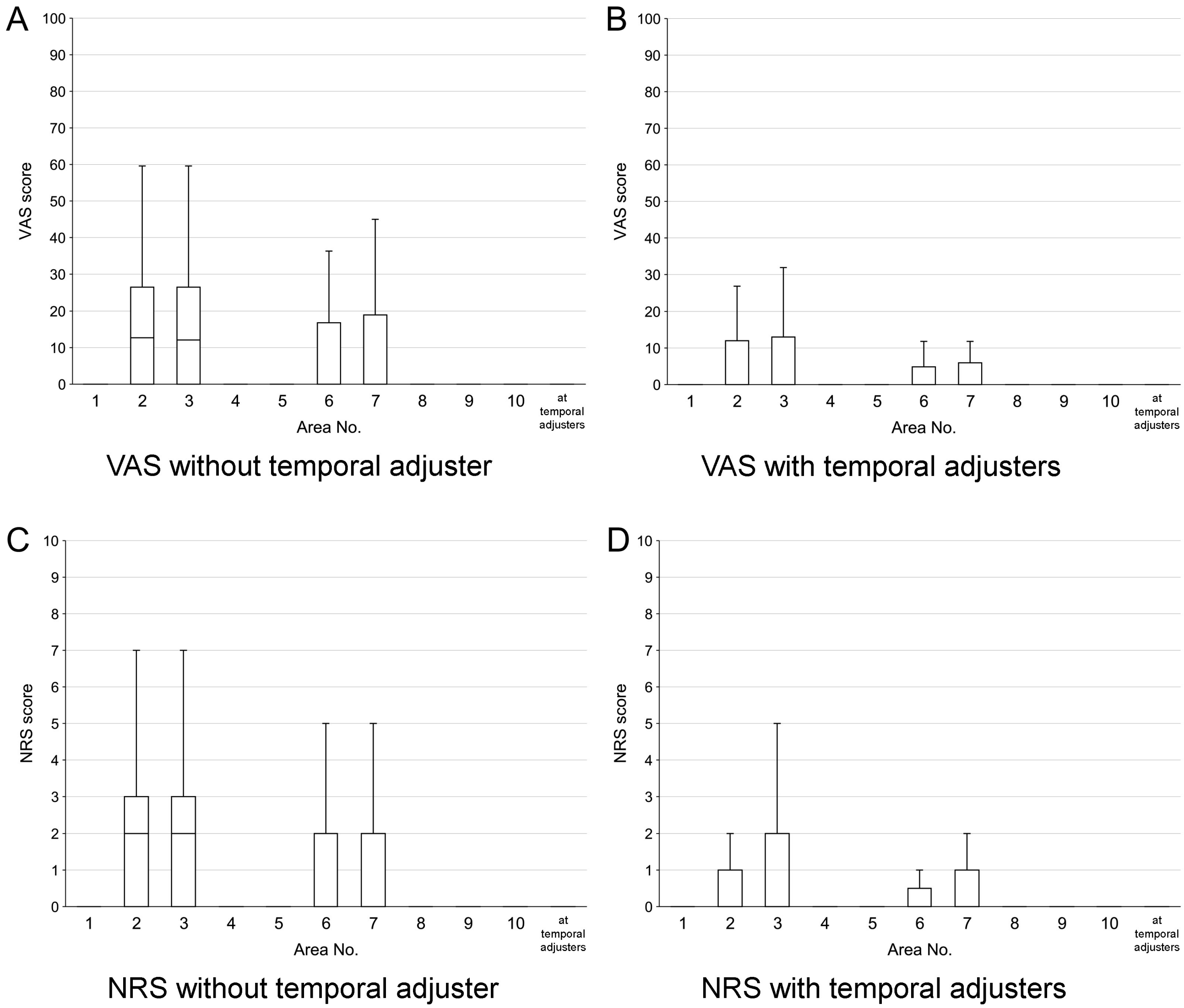
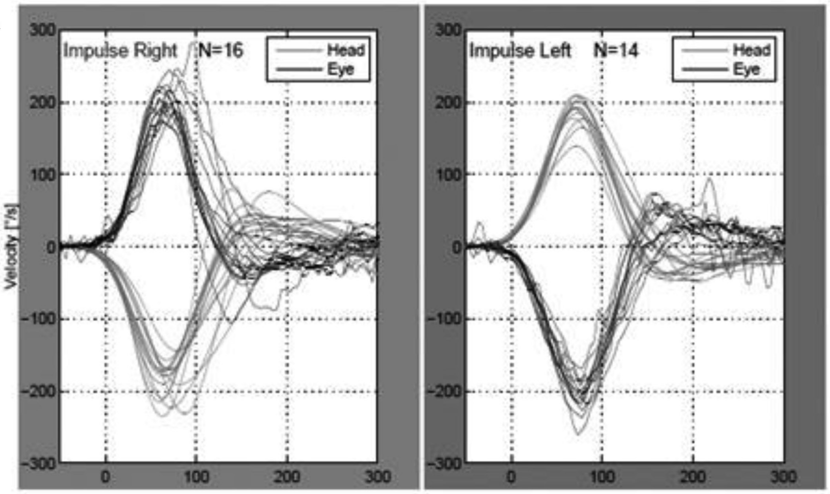


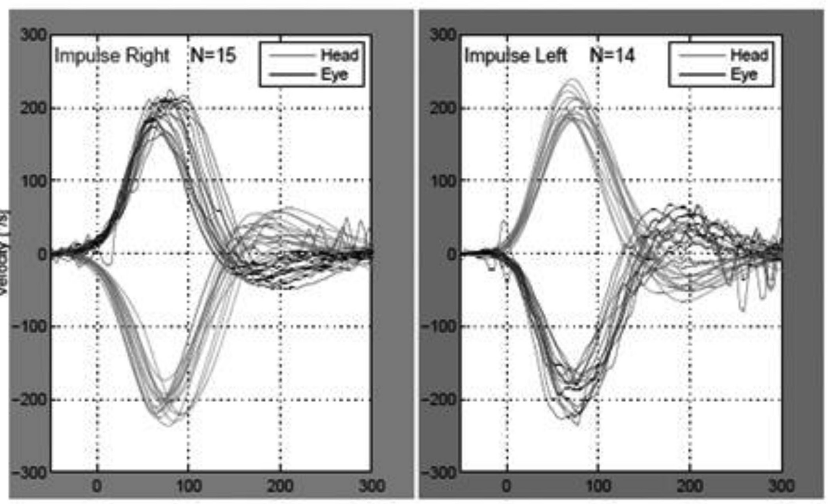
Supplemental Figure 1. VAS and NRS pain scores at 11 anatomic sites in 65 subjects. Points 6 and 7 on both sides of the temples and points 6 and 7 on the lateral orbital rims were areas in which the subjects reported significant goggle-induced pain. The VAS and NRS pain scores in both areas improved with the insertion of temporal adjusters. VAS, Visual Analog Scale, NRS, Numerical Rating Scale.

A



without temporal adjuster

B



with temporal adjusters

Supplemental Figure 2. Representative recordings of vHIT. None of the initial backward eye movement or acceleration and deceleration bumps were detected after the insertion of the temporal adjusters in the temple straps.