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Knowledge and application of correct car seat head restraint usage among chiropractic college interns: a cross-sectional study

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Summary of background data*: Cervical spine injuries sustained in rear-end crashes cost at least $7 billion in insurance claims annually in the United States alone. When positioned correctly, head restraint systems have been proven effective in reducing the risk of whiplash associated disorders. Chiropractors should be knowledgeable about the correct use of head restraint systems to educate their patients and thereby prevent or minimize such injuries.*

Objectives*: The primary objective of this study was to determine the prevalence of correct positioning of car seat head restraints among the interns at our institution. The secondary objective was to determine the same chiropractic interns' knowledge of the correct positioning of car seat head restraints. It was hypothesized that 100 percent of interns would have their head restraint correctly positioned within an acceptable range and that all interns would possess the knowledge to instruct patients in the correct positioning of head restraints.*

Study Design*: Cross-sectional study of a convenient sample of 30 chiropractic interns from one institution.*

Methods*: Interns driving into the parking lot of our health center were asked to volunteer to have measurements taken and to complete a survey. Vertical and horizontal positions of the head restraint were measured using a beam compass. A survey was administered to determine knowledge of correct head restraint position. The results were recorded, entered into a spreadsheet, and analyzed.*

Sommaire des données de base *: Les blessures à la colonne cervicale subies lors de collisions par l'arrière entraînent des coûts d'au moins 7 milliards de dollars aux États-Unis seulement. Lorsqu'ils sont positionnés correctement, les systèmes d'appuie-tête se sont avérés efficaces pour réduire les risques de troubles associés au coup de fouet cervical. Les chiropraticiens doivent être bien informés sur l'utilisation appropriée des systèmes d'appuie-tête afin de pouvoir éduquer leurs patients et prévenir ou réduire ainsi de telles blessures.*

Objectifs *: L'objectif principal de la présente étude était de déterminer la prévalence d'un positionnement adéquat des appuie-tête dans les véhicules des internes de notre institution. L'objectif secondaire était de déterminer les connaissances des mêmes internes en chiropractie sur le positionnement adéquat des appuie-tête dans les véhicules. L'hypothèse était que les appuie-tête de 100 % des internes seraient positionnés correctement à l'intérieur d'une plage acceptable et que tous les internes auraient les connaissances nécessaires pour éduquer leurs patients sur le positionnement adéquat des appuie-tête.*

Plan d'étude *: Étude transversale d'un échantillonnage pratique de 30 internes en chiropractie d'une institution.*

Méthodologie *: Nous avons demandé à des internes entrant dans le stationnement de notre centre de santé s'ils voulaient se porter volontaires pour la prise de mesures et la participation à une enquête. Les positions*

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Results: *13.3 percent of subjects knew the recommended vertical distance and only 20 percent of subjects knew the recommended horizontal distance. Chi Square analyses substantiated that the majority of subjects were unaware of guidelines set forth by the National Highway Traffic Safety Administration (NHTSA) for the correct positioning of the head restraint ($\chi^2_{vertical} = 16.13$, $\chi^2_{horizontal} = 10.80$, $p < .05$). Only 6.7 percent of the subjects positioned their head restraint at the vertical distance of 6 cm or less ($p < .05$). However, 60 percent of the subjects positioned their head restraint at the recommended horizontal distance of 7 cm or less, but this was no different than could be expected by chance alone ($p > .05$). Interestingly, the 13.3 percent of the subjects who were aware of the vertical plane recommendations did not correctly position their own head restraint in the vertical plane. Similarly, only half of the subjects who were aware of the horizontal plane recommendations correctly positioned their head restraint in the horizontal plane. The data suggest that chance alone could account for the correct positioning of the head restraint in our subjects.*

Conclusions: *The results of this cross-sectional study raise concerns about chiropractic intern knowledge and application of correct head restraint positioning. The importance of chiropractors informing patients of the correct head restraint position should be emphasized in chiropractic education to help minimize or prevent injury in patients involved in motor vehicle collisions.*
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KEY WORDS: cervical spine, injury, whiplash associated disorders, WAD, head restraint position, car seat, safety, chiropractic, intern.

verticale et horizontale de l'appuie-tête ont été mesurées à l'aide d'un compas à trusquin. Les participants devaient ensuite remplir un questionnaire afin de déterminer leurs connaissances sur la position adéquate des appuie-tête. Les résultats ont été enregistrés, convertis sous forme de tableaux et analysés.

Résultats *: 13,3 % des sujets connaissaient la distance verticale recommandée et seulement 20 % des sujets connaissaient la distance horizontale recommandée. L'analyse du khi-carré a corroboré que la majorité des sujets ne connaissaient pas les directives établies par la National Highway Traffic Safety Administration (NHTSA) pour le positionnement adéquat de l'appuie-tête ($x^2_{vertical} = 16,13$, $x^2_{horizontal} = 10,80$, $p < 0,05$). Seulement 6,7 % des sujets avaient positionné leur appuie-tête à la distance verticale de 6 cm ou moins ($p < 0,05$). Cependant, 60 % des sujets avaient positionné leur appuie-tête à la distance horizontale recommandée de 7 cm ou moins, mais cela était similaire au résultat auquel on pouvait s'attendre par la chance seulement ($p < 0,05$). Il est intéressant de noter que les 13,3 % des sujets qui connaissaient les recommandations sur le plan vertical n'avaient pas positionné correctement leur propre appuie-tête sur le plan vertical. De façon similaire, uniquement la moitié des sujets qui connaissaient les recommandations sur le plan horizontal avaient positionné correctement leur appuie-tête sur le plan horizontal. Les données suggèrent que la chance seulement pourrait expliquer le positionnement correct de l'appuie-tête chez nos sujets.*

Conclusions *: Les résultats de cette étude transversale soulèvent des préoccupations concernant les connaissances des internes en chiropractie sur le positionnement adéquat des appuie-tête. L'importance que les chiropraticiens soient en mesure d'informer leurs patients sur la position correcte des appuie-tête devrait être soulignée au cours de la formation en chiropractie afin d'aider à réduire ou à prévenir les blessures chez les patients impliqués dans des accidents de la route.*
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MOTS-CLÉS : colonne cervicale, blessure, troubles associés au coup de fouet cervical, WAD, position de l'appuie-tête, siège d'auto, sécurité, chiropractie, interne.

Introduction

In the United States alone, rear-end collisions account for approximately 30 percent of the estimated 6 million police-reported motor vehicle crashes annually.[1] In Canada, rear-end crashes are also very common.[2] According to the Insurance Institute for Highway Safety (IIHS), neck injuries sustained in rear-end crashes seldom are life-threatening, but they are painful, occur frequently and are expensive. In the United States alone, they cost at least $7 billion in insurance claims annually.[3] In such collisions, an occupant's unsupported head lags behind as the torso is accelerated forward. This phenomenon, of sudden differential motion, was first documented in 1928 and given the term 'whiplash'.[4] Many of these collisions result in minimal damage to the vehicle, however a significant number lead to symptoms of neck pain for occupants of rear-struck vehicles. These neck injuries have become increasingly common in motorized countries throughout the world.[5,6] Currently, this classification of injury is referred to as whiplash associated disorder (WAD).[7] This paper is concerned mainly with rear-end collisions because head restraint devices are designed to minimize or prevent injuries in this type of collision. It should be understood, however, that WAD is not restricted to rear-end collisions alone.

Passenger vehicle head restraints are padded extensions fitted to the tops of seatbacks in order to support the occupant's head in the event of a sudden acceleration/deceleration. Several studies conducted in the 1960s identified basic head restraint requirements to reduce whiplash injury.[8–10] As a result, the National Highway Safety Bureau devised the Federal Motor Vehicle Safety Standard 202[11] requiring by law all passenger cars manufactured for sale in the United States after December 31, 1968 and all pickups, vans, and utility vehicles manufactured after August 31, 1991 to have head restraints capable of extending to at least 700mm (27.5 inches) above hip level.[12] Similarly, since the 1970s, head restraints also have been mandated on new passenger cars sold in Canada, Europe and Australia.[13]

One issue that must be considered with regard to the proper use of head restraints is the ramping phenomenon. Ramping is the combined result of a person gliding up the seat back and a temporary straightening of the thoracic and cervical spinal curves during crashes. The impact of a crash results in the occupant's head rising above the head restraint, even when the head restraint is properly adjusted. In this situation, the head restraint may actually act like a fulcrum thereby intensifying the injury as the head crashes down onto the restraint and hammers it into a lower position.[14] Furthermore, head restraints on some vehicles are adjustable in the vertical plane but not in the horizontal plane.[15]

The IIHS has published ratings of head restraint geometry for most passenger vehicles sold in the United States since 1995.[13,16–18] The IIHS utilizes a protocol established by the Research Council for Automobile Repairs (RCAR) for evaluating the geometry of passenger vehicle head restraints that uses an H-point machine equipped with a standard Insurance Corporation of British Columbia (ICBC) head restraint measuring device (HRMD) to determine the static geometry of a vehicle head restraint. Ratings are based on measured vertical distances from the top of the restraint to the top of the head and horizontal distances from the front of the restraint to the back of the head of an average-sized male. (Figures 1, 2) Four rating categories have been identified: good, acceptable, marginal, and poor. (Figure 3) These evaluations have stimulated auto manufacturers to continually improve head restraint geometry. For the 1995 model year, only 13 of the 164 cars evaluated (8 percent) received good or acceptable head restraint ratings.[13,19] However, for the 2001 model year, 83 of the 166 cars evaluated (50 percent) received good or acceptable ratings.[18]

Since the mandate requiring head restraints was passed, the effectiveness of passenger vehicle head restraints in rear-impact collisions has been evaluated in many studies from the perspective of geometric design. Reductions in neck injury risk after the introduction of head restraints range from 9–18 percent for passenger cars.[20–24] However, neck injury rates still remained high, 24–37 percent of drivers in rear-struck cars, even for cars with head restraints.[16] Fixed (integral) head restraints were shown to be more effective than restraints that required manual adjustment to reach the 700mm height criterion, but this may have been because most drivers failed to properly position the adjustable head restraints.[16] It has been observed that the effectiveness of head restraints improves as they are positioned higher[25,26] and closer[27] to occupants' heads.

The standard of head restraint evaluation is from the perspective of geometric design. The external validity of

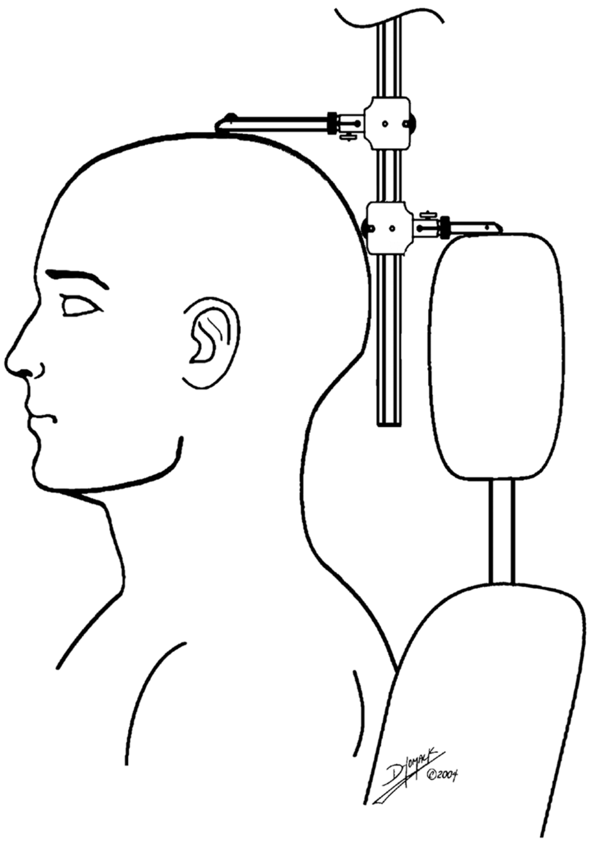

Figure 1 Vertical Distance. The vertical distance was measured form the most superior aspect of the top of the head to the top of the head restraint.

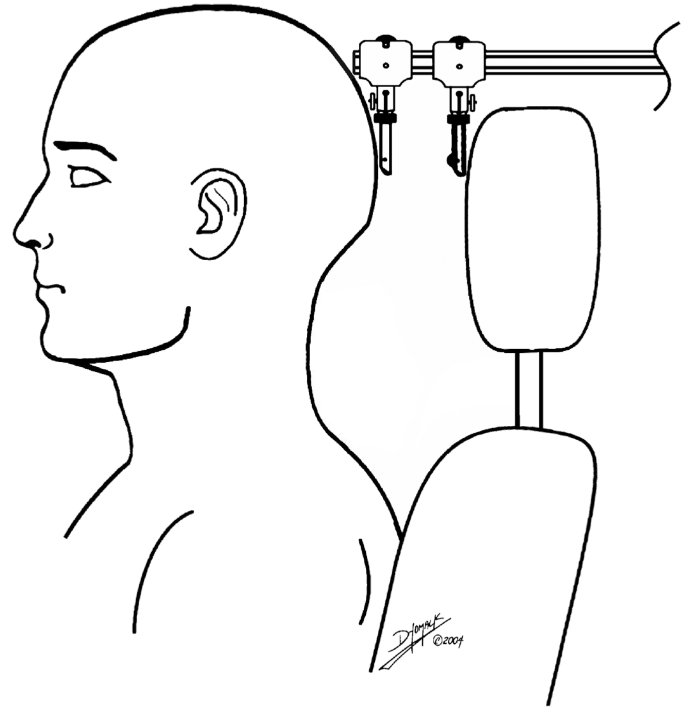

Figure 2 Horizontal Distance. The horizontal distance was measured from the most posterior aspect of the head to the most anterior surface of the head restraint.

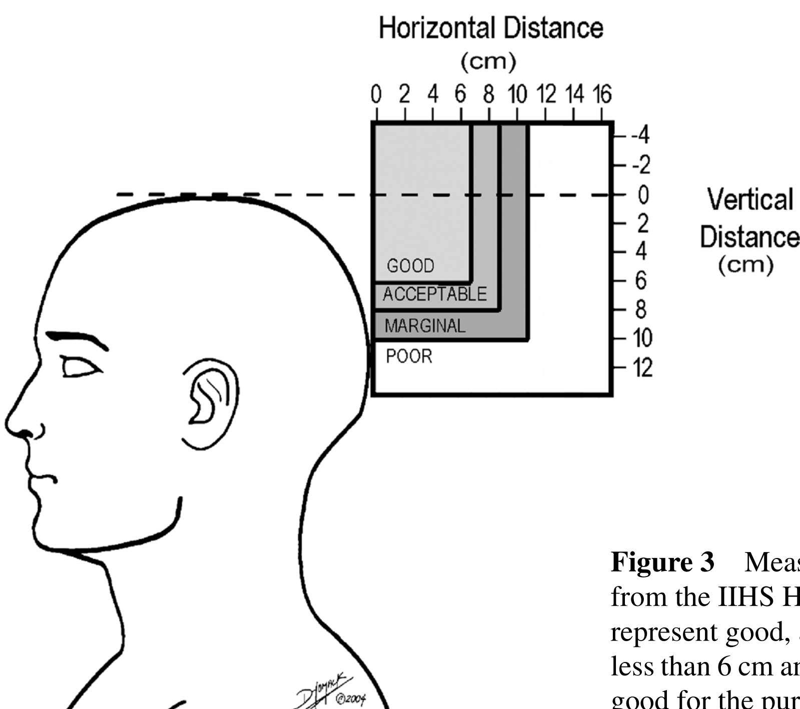

Figure 3 Measurements. This schematic diagram is re-drawn from the IIHS Head Restraint Guidelines. These geometric zones represent good, acceptable, marginal, and poor.[14] Vertical distances less than 6 cm and horizontal distances less than 7 cm are considered good for the purposes of our study.

this evaluation system comes into question when applied to real life situations, and it raises the question whether drivers actually employ their head restraint systems correctly. This problem has been recognized since the introduction of head restraints. Subsequently, a number of studies report that drivers often improperly adjust their vehicle head restraints.[28–31]

The purpose of this cross-sectional study was twofold: (1) To determine the prevalence of correct positioning of car seat head restraints among chiropractic interns from one institution and (2) To determine chiropractic interns' knowledge of the correct positioning of car seat head restraints. It was hypothesized that owing to the extensive instruction in our chiropractic college on WAD and how to prevent such injuries, 100 percent of interns would have their head restraints correctly positioned with good and acceptable ranges and that all interns would be knowledgeable enough to instruct patients in the correct positioning of head restraints.

Methods

After approval by the Institutional Review Board of New York Chiropractic College (NYCC) in April, 2002, a convenient sample of the first thirty chiropractic interns driving into the parking lot of one NYCC Health Center during one morning were asked to volunteer and to provide verbal informed consent form. One hundred percent of the interns (24 male, 6 female) volunteered to be measured. A beam compass and engineering ruler graduated in millimeters were used to make measurements of head restraint position. (Figure 4) The only inclusion criterion was the presence of a head restraint in the vehicle. Volunteers were asked to sit with hands on the steering wheel in their normal driving position while two measurements were obtained. The vertical distance was measured from the most superior aspect of the top of the head to the top of the head restraint. (Figure 1) The horizontal distance was measured from the most posterior aspect of the head to the most anterior surface of the head restraint. (Figure 2) The measurements were then recorded on a chart. After the measurements were obtained, every volunteer was then asked to complete a one-page written survey to determine their knowledge of correct head restraint position.

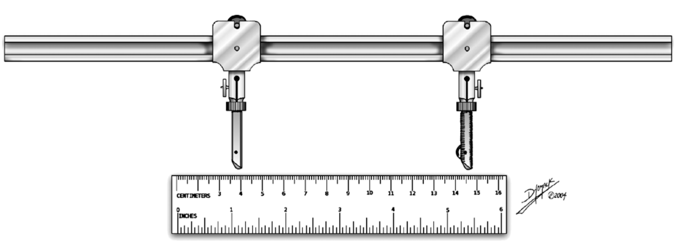

Figure 4 Beam Compass. The beam compass was used to measure vertical and horizontal measurements.

The results of the measurements and surveys were entered into a spreadsheet. Using the criteria set forth by the NHTSA to determine correct head restraint position, measurements within the following values were used for the purpose our study: (1) Vertical distance of less than 6 cm and (2) Horizontal distance of less than 7 cm. (Figure 3)

Statistical analyses included the chi square test (Goodness of Fit), calculations of the 95 percent confidence interval, and the one-sample t-test. SPSS was used to perform the statistical analyses.

Results

Measurements

Tables 1 and 2 summarize the data. Results indicated that only 6.7 percent of the subjects positioned their head restraint at the vertical distance of 6 cm or less. Chi square analysis substantiated that the majority of subjects incorrectly positioned their head restraint as compared to the guidelines set forth by NHTSA ($\chi^2 = 22.53$, $p < .05$). In addition, the 95 percent confidence interval for the vertical distance ranged from 10.7 cm to 13.1 cm indicating that the vertical position of the head restraint in this sample was significantly different from the criteria distance (t-value = 9.40, $p < .05$).

Sixty percent of the subjects positioned their head restraint at the NHTSA recommended horizontal distance of 7 cm or less. However, Chi Square analysis detected that correct positioning of the head restraint in the horizontal plane by 60 percent of the subjects was no different than could be expected by chance alone ($\chi^2 = 1.20$, $p > .05$). The 95 percent confidence interval for the horizontal distance ranged from 6.2 cm to 9.1 cm indicating that the horizontal position of the head restraint in this sample was not significantly different from the criteria distance (t-value = .91, $p > .05$).

Survey

Survey results indicated that only 13.3 percent of the subjects were aware of the recommended vertical distance and only 20 percent of the subjects were aware of the recommended horizontal distance. Chi Square analyses substantiated that the majority of subjects were unaware of guidelines set forth by NHTSA for the correct positioning of the head restraint ($\chi^2_{vertical} = 16.13$, $\chi^2_{horizontal} = 10.80$, $p < .05$). Interestingly, the 13.3 percent of the subjects who were aware of the vertical plane recommendations did not correctly position their own head restraint in the vertical plane. Similarly, only half of the subjects who were aware of the horizontal plane recommendations correctly positioned their head restraint in the horizontal plane. (Table 3)

Discussion

Our hypothesis is not supported by the data obtained. These data suggest that chance alone could account for the correct positioning of the head restraint in our subjects. The results raised concerns regarding the lack of knowledge of the correct head restraint position and also the paucity of subjects demonstrating correct positioning at this chiropractic college.

The method of measurement employed in this cross-sectional study mimicked the RCAR protocol by the use of a beam compass and manual measurement of drivers' seated within their own vehicle. (Figures 1–2) A number of limitations in the method of measurement became evident during and after completion of our study. One major limitation is the unexpected intrusiveness of the process, which may have lead to subjects leaning forward away from the beam compass. Subject sway and variability of subject posture can significantly impact results since the range of measurement between ratings is relatively small. Another major concern with this measurement system is that it assumes that driving posture is static, where in fact driving is very much a dynamic activity, especially in urban scenarios where collisions are common. The position of the head in relation to the head restraint varies constantly, and the use of static measurements of head restraint usage diminishes external validity and makes it difficult to draw conclusions based on these results.

Based on the results of this cross-sectional study, similar more extensive testing should be performed on a larger population. A number of factors should be considered

Table 1 Proportions of Volunteers Correctly Positioning the Head Restraint by Meeting the Good Criterion.

	Correct (n, percentage)	Incorrect (n, percentage)
Vertical Plane	2 (6.7%)	28 (93.3%)
Horizontal Plane	18 (60.0%)	12 (40.0%)

Table 2 The Results from the Beam Compass Measurements as Compared to the Criteria Set Forth by NHTSA.

	Criterion Values (cm)				Measured Values (cm)	
Planes	Good	Acceptable	Marginal	Poor	Mean ± SD	95% CI
Vertical	≤6	≤8	≤10	>10	11.9 ± 3.44	10.7–13.1
Horizon tal	≤7	≤9	≤11	>11	7.7 ± 3.93	6.2–9.1

Table 3 Survey Results Representing Knowledge of the NHTSA Criteria.

	Yes (n, percentage)	No (n, percentage)
Vertical Plane	4 (13.3%)	26 (86.7%)
Horizontal Plane	6 (20.0%)	24 (80.0%)

before designing such a study. From a measurement standpoint, the use of digital photography or video technology instead of the beam compass method may provide a better representation of driver head position. Digital photography or video technology would more accurately document the driver's head position while the subject is engaged in driving and would reduce measurement error associated with the more invasive beam compass method. However, precise mounting and calibration of recording equipment in a field study is more problematic than the simple beam compass method.

Secondly, there have been innovations in head restraint designs that compensate for changes in driver head position during impact. Saab,[32–35] Toyota,[36] and Volvo[37,38] are three leading automobile manufacturers incorporating active head restraint systems in their new models. These active head restraints are new approaches to reducing whiplash injury risk and they have been justified both theoretically and in the laboratory; however, they require further testing in actual collision situations. As these new design strategies become more popular in production vehicles, more dynamic approaches to testing must be determined to ensure the correct use and safety of active head restraints.

Despite the limitations listed above, and despite the fact that more reliable and valid methods to statistically assess the correct usage of head restraints have yet to be devised and tested, it is widely agreed that every attempt should be made to position head restraints correctly. Chiropractors are ideally suited to inform patients of the importance of correct head restraint position and chiropractic education should emphasize this knowledge.

Conclusion

Accurate measurement of head restraint position is difficult to achieve. Furthermore, the results of this cross-sectional study raise concerns about the knowledge and application of correct head restraint position among chiropractic interns. Our study examined interns from only one institution and the authors encourage other chiropractic institutions to perform similar studies of their interns. A chiropractic education should emphasize the importance of patient awareness of correct head restraint positioning to minimize or prevent injury in patients involved in motor vehicle collisions.

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