

## CHRISTMAS 2008: MUSIC

## Head and neck injury risks in heavy metal: head bangers stuck between rock and a hard bass

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## ABSTRACT

**Objective** To investigate the risks of mild traumatic brain injury and neck injury associated with head banging, a popular dance form accompanying heavy metal music.

**Design** Observational studies, focus group, and biomechanical analysis.

**Participants** Head bangers.

**Main outcome measures** Head Injury Criterion and Neck Injury Criterion were derived for head banging styles and both popular heavy metal songs and easy listening music controls.

**Results** An average head banging song has a tempo of about 146 beats per minute, which is predicted to cause mild head injury when the range of motion is greater than 75°. At higher tempos and greater ranges of motion there is a risk of neck injury.

**Conclusion** To minimise the risk of head and neck injury, head bangers should decrease their range of head and neck motion, head bang to slower tempo songs by replacing heavy metal with adult oriented rock, only head bang to every second beat, or use personal protective equipment.

## INTRODUCTION

Young people at heavy metal concerts often report being dazed and confused, possible symptoms of mild traumatic brain injury. Little formal injury research has been conducted on the world wide phenomenon of head banging, even though case reports indicate the inherent risks in this activity, especially in head and neck injury. Head banging is a violent activity associated with hard rock and various subgenres of heavy metal. Over the past five years hard rock and heavy metal have contributed to about 30% of all record sales in the United States<sup>1</sup> and, as of 2002, rock albums have outsold pop albums.<sup>2</sup> The second highest selling album of all time is AC/DC's *Back in Black*, which has sold about 42 million copies worldwide.<sup>3</sup> Two slightly more recent albums, Bon Jovi's *Slippery When Wet* and Guns N' Roses' *Appetite for Destruction*, have each sold about 28 million copies.<sup>4,5</sup> Though exposure to head banging is enormous, opportunities are present to control this risk—for example, encouraging bands such as AC/DC to play songs like “Moon

River” as a substitute for “Highway to Hell”; public awareness campaigns with influential and youth focused musicians, such as Sir Cliff Richard; labelling of music packaging with anti-head banging warnings, like the strategies used with cigarettes; training; and personal protective equipment.

The head banging story begins in 1968 when Led Zeppelin was playing a set at the Boston Tea Party on their first US tour. The front rows of the audience were banging their heads on the stage in time to the music and the term “head banger” was born.<sup>6,7</sup> It now refers to violent and rhythmic movement of the head synchronous with music, most commonly heavy metal music.<sup>8</sup> It has etched its mark in popular culture with the likes of Beavis and Butt-head banging their heads instead of reviewing video clips for songs, with the first of these being “I Wanna Be Sedated” by The Ramones.<sup>9</sup> Head banging was popularised in the movie *Wayne's World* when Wayne, Garth, and friends started head banging to Queen's epic ballad “Bohemian Rhapsody.”<sup>10</sup>

There are many different styles of head banging such as the up-down, the circular swing, the full body, or the side-to-side. It is thought that head banging to loud music, while making you more “metal,” has associated risks other than acquired hearing loss.<sup>11</sup> Jason Newsted, known for his circular swinging style head banging, gave “physical damage” as one of the reasons for his departure from the band Metallica in 2001.<sup>12</sup> In 2005, doctors believed that Terry Balsamo, the guitarist from the band Evanescence, experienced a stroke from head banging.<sup>13</sup> Head banging caused a traumatic aneurysm of the cervical vertebral artery in a 15 year old drummer,<sup>14</sup> and one case of subdural haematoma was reported to be caused by the shearing strain induced by the head and neck motion exhibited during head banging.<sup>8</sup> Even though there are only a few unique cases documented, neurosurgical specialists question whether the incidence rate could be much higher because the symptoms are clinically silent or cause only mild headache that resolves spontaneously.<sup>8</sup> We investigated the injury risk arising from head banging using biomechanical methods and the possible methods for controlling those risks.

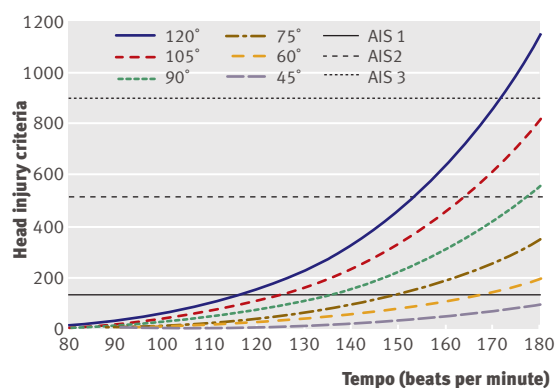
## METHODS

We conducted an observational study to identify the most popular head banging technique. We attended several hard rock and heavy metal concerts to find the most common style of head banging executed by audience members. The bands performing at these concerts included Motörhead, Mötley Crüe, Skid Row, The Hell City Glamours, L.A. Guns, Ozzy Osbourne, Winger, Ratt, Whitesnake, and W.A.S.P. It was evident that most people engaging in head banging chose to perform the up-down style.

Using the results of the observational study, we undertook biomechanical analyses. Previous studies have shown that angular head velocity, and therefore also angular displacement and acceleration, during head oscillation in pitch are approximately sinusoidal.<sup>15</sup> Therefore we constructed a theoretical head banging model with the basic assumption that the angular displacement of the head during head oscillation in pitch follows a sinusoidal motion in the sagittal plane with the T1-C7 joint acting as the axis of rotation. We used reported coordinates of the centre of gravity of the head and the T1-C7 joint for a 50th centile adult male (table 1) and calculated the radius of rotation of the head to be about 174.0 mm.

The amplitude of the displacement curve was based on the range of motion of the cervical spine of an adult male—60.4° flexion and 69.9° extension,—giving a total of 130.3°.<sup>18</sup> Therefore we varied the range of motion from 45° to 120° by increments of 15° to investigate the effect that the range of motion has on injury severity.

We varied the range of angular displacement of the head and neck and the frequency of the movement in the theoretical model and derived Head Injury Criterion (HIC) and Neck Injury Criterion (NIC) levels (see equations 1 and 2, respectively). HIC was related to the abbreviated injury scale and



**Fig 1** | Head banging tempo v the Head Injury Criteria (HIC) for various head and neck ranges of motion (45° to 120°). Abbreviated injury scale thresholds indicated as horizontal lines

established injury thresholds (table 2). It is recognised that there are limitations in the interpretation of HIC in the absence of a direct head impact.

$$HIC = \left\{ (t_2 - t_1) \left[ (t_2 - t_1)^{-1} \int_{t_1}^{t_2} a(t) dt \right]^{2.5} \right\}_{\max}$$

Where  $t_1$  and  $t_2$  are the initial and final times of the interval during which the head injury criteria attains a maximum value and  $a(t)$  is the resultant acceleration measured at the centre of gravity of the head.

The originally proposed human tolerance for NIC was  $15 \text{ m}^2/\text{s}^2$ .<sup>20</sup> Several studies, however, disagree with this, as people have experienced neck injury when the measured criteria never exceeded  $15 \text{ m}^2/\text{s}^2$ .<sup>21</sup> This threshold is now used for long term symptoms,<sup>22</sup> and a more recent study proposed  $8.7 \text{ m}^2/\text{s}^2$  as a threshold for acute soft tissue injury.<sup>23</sup>

$$NIC = 0.2a_{rel} + v_{rel}^2$$

Where  $a_{rel}$  and  $v_{rel}$  are the acceleration and velocity of the head's centre of gravity relative to the T1 vertebra.

We asked a focus group of 10 musicians from local bands to nominate their favourite head banging song. Musical training or talent was not a prerequisite for membership of this group. The focus group voted on each song, and we compiled an ordered list of the top 11 songs. As each song was played, members of the focus group were asked to tap out the beat of the song for the duration of one minute, so we could calculate the average tempo of each song. We chose this rather than direct measurement of tempo because it reflects the head banger's potential actions when exposed to this music.

We randomly selected three songs ("I Will Always Love You" by Whitney Houston, "Hello" by Lionel Ritchie, and "Babe" by Styx) from on-line lists of easy listening and adult oriented rock as musical controls.

## RESULTS

Figure 1 shows HIC versus music tempo and thresholds for severity of head injury according to abbreviated injury scale 1, 2, and 3. If the head and neck range of motion exceeds 45° there are definite risks of mild traumatic brain injury related to the range of motion and tempo. Figure 2 shows NIC versus music tempo. The injury thresholds are indicated on the graph. There is an increasing risk of neck injury starting at tempos of 130 beats per minute related to the range of motion in the head banging style.

**Table 1** | Coordinates of head's centre of gravity (CG) and C7-T1 joint for a 50th centile adult male<sup>16 17</sup>

|       | x (mm) | z (mm) |
|-------|--------|--------|
| CG    | 8.2    | 28.2   |
| C7-T1 | -8.0   | -145.0 |

## DISCUSSION

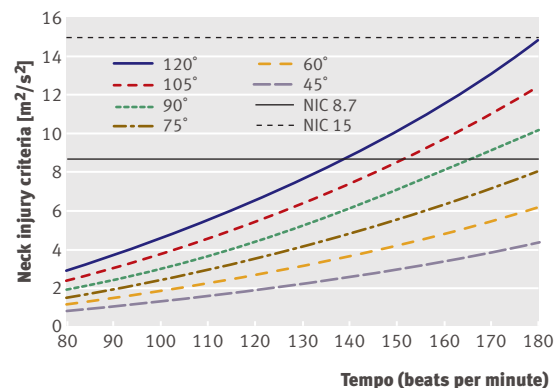
The top 11 head banging songs chosen by the focus group were all performed by hard rock or heavy metal artists, even though there was no restriction placed on genre. These songs had an average tempo of 146 beats per minute, and at this tempo we predict that head banging can cause headaches and dizziness (dazed and confused) if the range of movement of the head and neck is greater than 75°. Head banging at 146 beats per minute with 105° range of motion can cause NIC to exceed 8 m<sup>2</sup>/s<sup>2</sup>, which is the lowest injury threshold. Therefore, predicted risks for acute neck injury with moderate tempo heavy metal and limited neck motion in our model are limited.

Many hard rock and heavy metal bands play fast tempo songs, such as Spinal Tap's "Tonight I'm Gonna Rock You Tonight" and "Kickstart My Heart" by glam metal band Mötley Crüe, both with tempos around 180 beats per minute. If someone were to head bang at this tempo with 120° range of motion, the Neck Injury Criterion (fig 2) is in the vicinity of the long term injury threshold of 15 m<sup>2</sup>/s<sup>2</sup>. For the same tempo and range of movement the Head Injury Criterion (fig 1) predicts that the activity will result in abbreviated injury scale level 3 injuries, and that the range of motion of the head must be below 45° for level 1 injuries to be avoided. It is at this point that the question of whether someone can render themselves unconscious while head banging needs to be asked. It would be more likely for this to occur if someone was banging their head on the stage while in the first row of a Led Zeppelin concert or if they were coming in contact with the head of another audience member. The physical limitations of the neck muscles make it difficult for the head to travel through a large range of movement while head banging to songs of such a high speed.

We can also use the theoretical model to estimate the injury levels to two of the greatest head bangers, Beavis and Butt-head. When head banging at a tempo of 164 beats per minute to "I Wanna be Sedated"<sup>9</sup> the range of motion of Beavis' head and neck is about 45°, which is

**Table 2** Abbreviated injury scale (AIS), Head Injury Criterion (HIC), and symptoms of head injury<sup>19</sup>

| AIS | HIC      | Symptoms                  |
|-----|----------|---------------------------|
| 1   | 135-519  | Headache or dizziness     |
| 2   | 520-899  | Unconsciousness <1 hour   |
| 3   | 900-1254 | Unconsciousness 1-6 hours |

**Fig 2** | Head banging tempo v Neck Injury Criterion (NIC) for various head and neck ranges of motion (45° to 120°). Abbreviated injury scale thresholds indicated as horizontal lines

below any injury threshold of both the head and neck injury criteria. Butt-head, however, preferred to head bang with a range of motion of about 75°. This activity is below any Neck Injury Criterion threshold, but level one head injuries are predicted by the Head Injury Criterion, with the symptoms being headaches and dizziness. It is well understood, however, that cartoon characters are able to tolerate greater than normal impacts without injury. Another legendary pair of head bangers, Wayne and Garth, head bang to "Bohemian Rhapsody" at 138 beats per minute with a range of movement of about 45°. Because of the low range of movement, no injuries were predicted by either the head or neck injury criteria, though the characters in the back seat of the car demonstrated a noticeably larger range of motion and might be at risk of head or neck injury.

The head and neck injury criteria are designed to analyse single acceleration peaks and not periodic acceleration curves. For HIC, there is debate about its use in the absence of a direct impact to the head. There are no established injury criteria or risk assessment that consider the cumulative effects of repetitive head movement in one session, when someone might have shaken all night long, or multiple sessions of head banging. Use of a scaling factor, which is a function of the time duration of the activity, would be one possible solution to this limitation.

Possible interventions to reduce the risk of injury caused by head banging include limiting the range of neck motion through a formal training programme delivered before a concert; substitution of adult oriented rock and easy listening music such as the controls, or others including Michael Bolton, Celine Dion, Enya, and Richard Clayderman, for heavy metal; and personal protective equipment such as neck braces to limit range of motion. Future research will involve neuropsychological testing of concert

**WHAT IS ALREADY KNOWN ON THIS TOPIC**

Case reports indicate that head banging might cause brain and neck injury

Head banging to heavy metal is a popular dance form

**WHAT THIS STUDY ADDS**

The application of biomechanical methods identified a definite risk of mild traumatic brain injury from head banging

The study helps to explain why metal concert goers often seem dazed, confused, and incoherent

goers to validate the modelling presented in this paper, and randomised controlled trials of musical substitutes.

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