November 1, 2024

MEA File Number: 146736

Technical Safety BC
Suite 600 – 2889 East 12th Avenue
Vancouver, BC
V5M 4T5

Attention: Mr. Ryan Hazlett

Re: Whistler Passenger Bobsleigh Experience
Incident Dates: November 22, 2023 & February 10, 2024
Your File No.: 41740

Attached please find my Injury Biomechanics Report for the above-captioned matter. My conclusions can be found on page 14. The assumptions and analysis behind these conclusions are described in earlier sections of the report.

If you have any questions or additional requirements, please call. Thank you for asking me to assist you in this matter.

Yours very truly,
MEA Forensic Engineers & Scientists Ltd

Dennis D Chimich, MSc, PEng
Senior Biomechanical Engineer

Enclosure: Injury Biomechanics Report

Injury Biomechanics Report

Re:	Whistler Passenger Bobsleigh Experience
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Prepared for:

Technical Safety BC
Suite 600 – 2889 East 12th Avenue
Vancouver, BC
V5M 4T5

Principal Author:

Dennis D Chimich, MSc, PEng
Senior Biomechanical Engineer

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1.0 QUALIFICATIONS

I, Dennis D Chimich, MSc, PEng, am responsible for the content of this report. I am a Senior Biomechanical Engineer at MEA Forensic Engineers & Scientists and registered as a Professional Engineer in British Columbia, Alberta, and Ontario.

I have been involved in over 3000 injury investigations involving injury causation and the biomechanics of injury. In addition to my consulting work, I have conducted studies on occupant motion, mechanics of injury in automobile collisions, slips and falls, and the impact attenuation behaviour of motorcycle and bicycle helmets. My curriculum vitae is attached in Appendix A.

2.0 INSTRUCTIONS

Further to our conversations, I reviewed some of the provided materials (Appendix B) and conducted an assessment of the thoracic and lumbar compression fracture injuries attributed to the 4-person Public Passenger Bobsleigh Experience at the Whistler Sliding Centre.

3.0 BACKGROUND

I have assumed the following for the purposes of this report:

3.1 Factual Assumptions

1) The public passenger bobsleigh experience includes the lower 10 curves of the track, with the start between curves 6 and 7 and the final curve being 16.

2) The pilot of the bobsleigh is located in seat 1. Directly behind the pilot is seat 2, directly behind 2 is 3, and the rearmost seat is 4.

3) The vertical (i.e. z-axis) accelerations experienced by the riders/occupants in seats 2, 3 and 4 are similar.

4) The maximum vertical accelerations occur at curve 16.

5) The maximum vertical accelerations are 4-4.5g, depending on rider weight and the sled.

6) The bobsleighs used for the public passenger experience differ from those used in racing. Specifically, they have taller sides, wider seats that include padding, foot pegs for the feet, cables for each participant to hold for the duration of the run, and braking is done by the pilot (Figure 1).

Figure 1. Provided photographs of the bobsleigh design used for the public experience.

3.2 Injury and Incident Descriptions

Various levels of detail for the incidents and reported back injuries were provided. I have briefly summarized each below.

November 22, 2023

[redacted] was 51 years of age, 5'10" and 176 lbs. It was noted that she had a history of low back and sacrum region issues treated with massage therapy and osteopathy. A bone mineral density study done about 5 months after the incident was reported to be normal (i.e. no osteoporosis).

I understand that [redacted] was in the 4th seat of the bobsleigh (i.e. seated at the back) and felt pressure during curve 16 (the final curve of the run). She was diagnosed with a L1 compression/burst fracture with a described ~40-50% loss of anterior vertebral body height and 10% loss of posterior vertebral body height with associated mild ~4mm posterior retropulsion resulting in mild spinal canal narrowing. This fracture was classified as Type B1. Also reported was a T12 spinous process fracture.

February 10, 2024

[redacted] was 48 years of age and 5'10". It was noted that he had a history of probable rheumatoid arthritis.

[redacted] was seated in the 4th seat of the bobsleigh. He described his back getting more and more compressed in the 2nd or 3rd to last curves and that he eventually felt the wind knock out of him. He was diagnosed with T9 and T11 compression fractures. T9 was described as type A2 with a split pattern of both endplates, wedge compression with ~30% loss of anterior vertebral body height and minimal buckling of the posterior cortex. T11 was described as type A3 with single endplate involvement, violation of the posterior vertebral wall and superior endplate compression with minimal anterior vertebral body height loss.

Other incidents

March 17, 2012: Unknown rider in 4th seat with mention of corner 13 and a lower back injury (fracture not confirmed).

March 12, 2015: A male 40 years of age, 6'3", 234 lbs in the 4th seat described a jarring motion and pain through corner 16. He was speculated to have a history of back problems and noted "poor posture". His injury was described as stable fractures of T11 and T12.

February 2, 2016: A female 55 years of age, 5'4", 168 lbs in the 4th seat described a crack and pain at the lower part of the course. Her injury was described as a lumbar compression fracture.

February 5, 2016: A female 45 years of age, 5'8", 119 lbs in the 2nd seat had a history of prior vertebral compression fracture. Pain without fracture was described.

December 3, 2018: A female 58 years of age with described lumbar muscle strain.

May 23, 2019: A female 66 years of age, 139 lbs with a history of prior back strain and osteoporosis. Her injury was described as L4-5 pain.

February 3, 2020: A female 50 years of age in the 2nd seat with described T7 transverse process fracture.

February 26, 2020: A female 63 years of age in the 4th seat with described stable L1 compression fracture.

March 2, 2023: A male 37 years of age, 5'11", 218 lbs in the 4th seat with described stable L1 fracture.

While much data is missing, the above data have been compiled and show the following:

- Sex: 3 males, 7 females, 1 unknown
- Age (years): 37-63 (range), 51.3 (average), 1 unknown
- Height (feet-inches): 5'4"-6'3" (range), 5'10" (average), 5 unknown
- Seat in bobsleigh: 2 (seat 2), 7 (seat 4), 2 unknown
- Curve where injury occurred: 1 (curve 13), 2 (lower part of course), 2 (curve 16), 6 not reported
- History: 3 (back issues, not fractures), 1 (previous fracture), 1 (osteoporosis), 1 (probable rheumatoid arthritis), 1 (poor posture), 6 unknown

4.0 ANALYSIS

Biomechanical analyses of injury generally consist of determining the mechanical loads needed to disrupt various tissues and demonstrating consistency or inconsistency between the applied mechanical stimulus and a diagnosed injury.

For my analysis, I first examine spinal anatomy and geometry to understand how the spine would be loaded in this incident. I then assess the injury mechanism and threshold for the documented compression fractures while considering factors that influence fracture tolerance. Lastly, I compare this to the known loading exposure.

4.1 Spinal Anatomy and Posture

The spine is composed of bony vertebrae with 7 in the cervical region, 12 in the thoracic region and 5 in the lumbar region (Figure 2). Each pair of vertebrae are connected by three joints: anteriorly through an intervertebral disc and posteriorly through two facet joints (Figures 2 and 3). The vertebrae increase in size as one descends from the cervical region to the lumbar region. The reported vertebral fractures in the provided medical documents largely occurred in the lower thoracic and upper lumbar regions of the spine and as such I will focus my analysis in these regions. In these areas, the spine has a lordotic or backwards bending posture when standing (Figure 2).

The body or spinal posture determines how and where the vertebrae will be loaded during vertical compressive loading of the spine. Depending on the specific posture, the distribution of the forces acting on the different aspects of a given vertebra will vary. For example, a flexed forward posture will apply the force more on the anterior body or forward aspect of the vertebra where as a straight or extended posture will move the loading areas on the vertebra rearward toward the facets and spinous process (Figure 3).

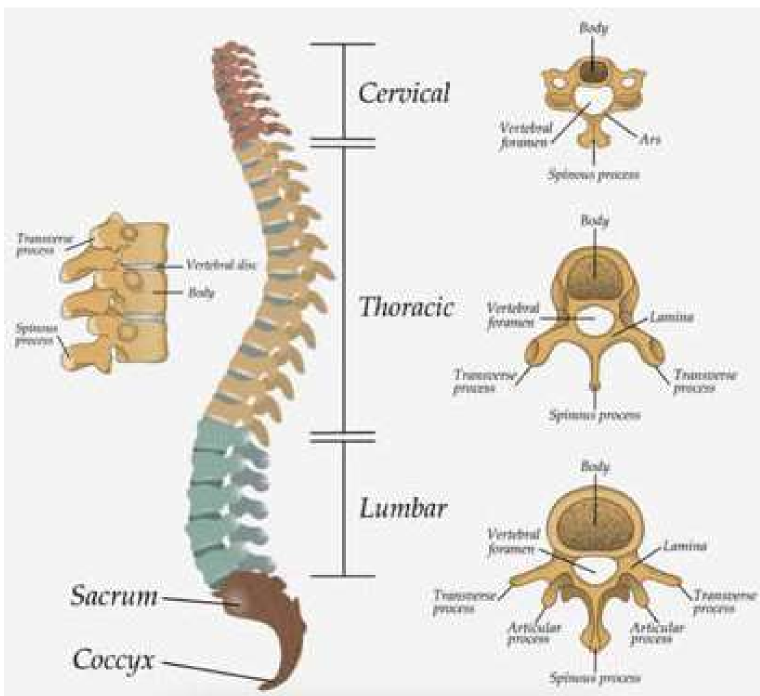

Figure 2. Illustration of spinal anatomy (https://www.stemxgroup.com/conditions/facet-syndrome/) in side and top views. The front of the vertebral body represents the anterior or front of the spine whereas the spinous process represents the back or posterior aspect of the vertebra/spine.

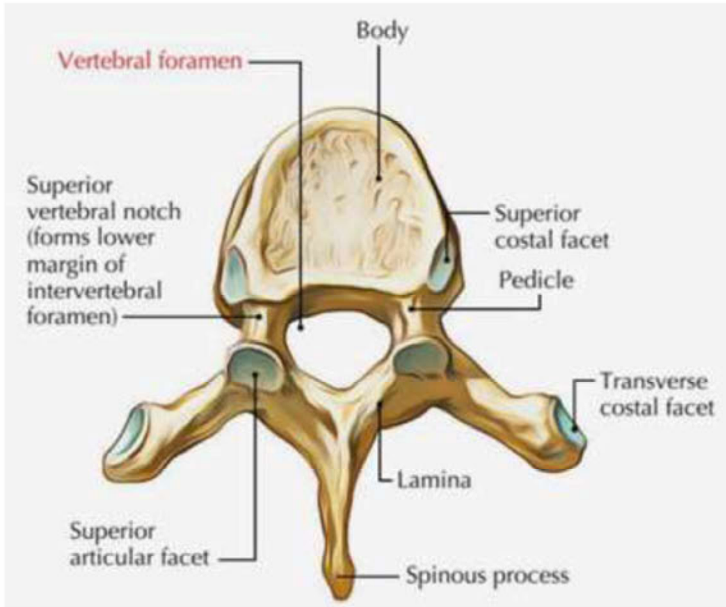

Figure 3. Top view illustration of vertebra showing body and facet locations in the spine (https://www.stemxgroup.com/conditions/facet-syndrome/).

In a standing posture the lumbar spine is in a normal position of lordosis and naturally in a position of extension (Figure 4). In a seated posture, the lumbar spine straightens and is in a position of relative flexion compared to standing. The seated posture moves the loading area more forward on the vertebra compared to a standing posture.

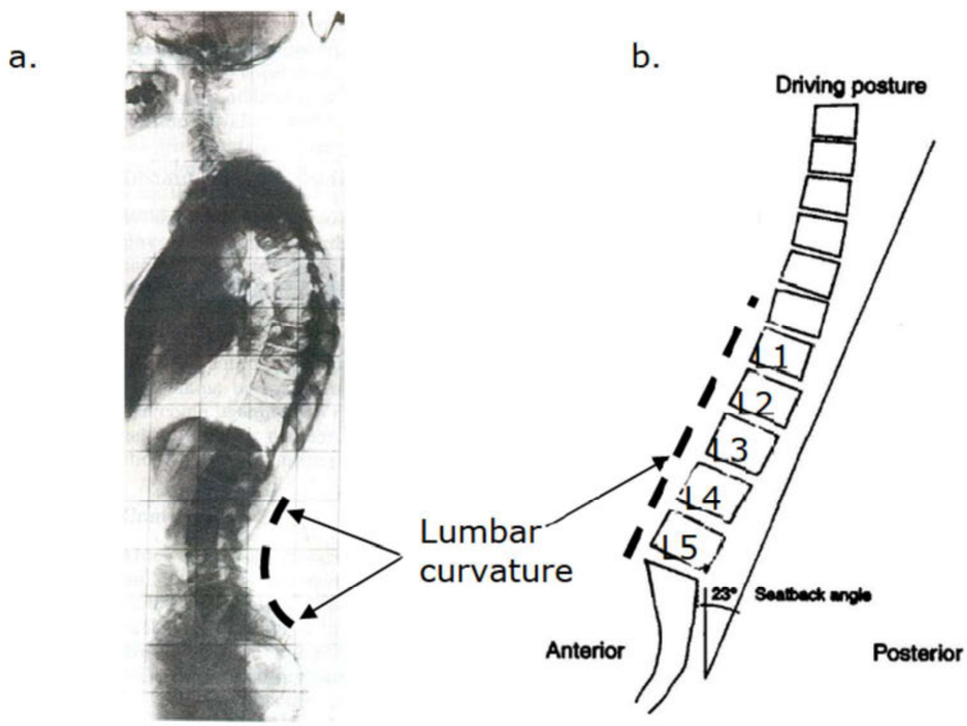

Figure 4. The curvature of the lumbar spine while (a) standing (adapted from White and Panjabi,1990) and (b) sitting in an automobile seat (adapted from Banks et al., 2000).

The seated spinal posture shown in Figure 4 is from the driver's seat of a motor vehicle with the seatback reclined rearward 23 degrees from vertical. An upright or more forward seated posture would result in more lumbar spine flexion than observed in Figure 4.

4.2 Injury Mechanics, Threshold, and Exposure

Injury Mechanics

As noted above, [redacted] was diagnosed with an L1 compression/burst fracture with a described ~40-50% loss of anterior vertebral body height and 10% loss of posterior vertebral body height. Although the diagnosis is a compression/burst fracture, the described ~40-50% loss of anterior vertebral body height in comparison to the 10% loss of posterior vertebral body height also demonstrates an anterior wedge compression pattern.

[redacted] was diagnosed with T9 and T11 compression fractures. The T9 vertebra was further labelled as a wedge compression with about 30% loss of anterior vertebral body height and minimal buckling of the posterior cortex. Again, the focused loss of anterior vertebral body height is consistent with an anterior wedge compression pattern/loading.

Burst fracture patterns result from a vertical compressive load acting along the long axis of the spine (Fredrickson et al., 1992; White and Panjabi, 1990; Garfin et al., 1998) (Figure 5A). In upright standing, the spine is in a relatively neutral position and the thoracolumbar junction is largely straight. Landing on the feet while upright provides a vertical compressive force through the straight spine which is a mechanism for a burst type fracture (Bolesta et al., 1996). With the comminution often associated with burst fractures, these fractures are assumed to be high-energy impact fractures secondary to rapid vertical compressive loading.

A wedging fracture pattern results from a compression force acting anterior to the axis of rotation so that a bending or flexion moment is also applied to the vertebral body resulting in greater compressive forces to the front of the vertebral body (White and Panjabi, 1990; Bolesta et al., 1996; Garfin et al., 1998) (Figure 5B). Wedging patterns can also occur when a compressive load is applied through a pre-flexed spine (Kifune et al, 1997), like the pre-flexed spine position observed when in a seated posture.

When compressive loading is applied through a flexed spine, like during vertical loading through the buttocks while in a seated position, compression and flexion forces are applied which provide a mechanism for an anterior wedge type compression fracture (McGill and Callaghan, 1999). Kikuike et al.,(2008) described a series of five patients who jumped into a river and sustained thoracolumbar burst fractures with some degree of anterior wedging or kyphosis. The fractures were hypothesized to occur from axial load and flexion force when individuals jumped with their backs and hip joints flexed and landed on their buttocks or femurs against the water.

[redacted] diagnosed burst fracture pattern with marked wedge compression characteristics typically results from an axial compressive load to the spine with a flexion moment also present. [redacted] burst/wedge compression fracture pattern is from compressive loading of her spine while seated with her spine in a pre-flexed position to allow for flexion moment loading and anteriorly focused forces on the vertebral body.

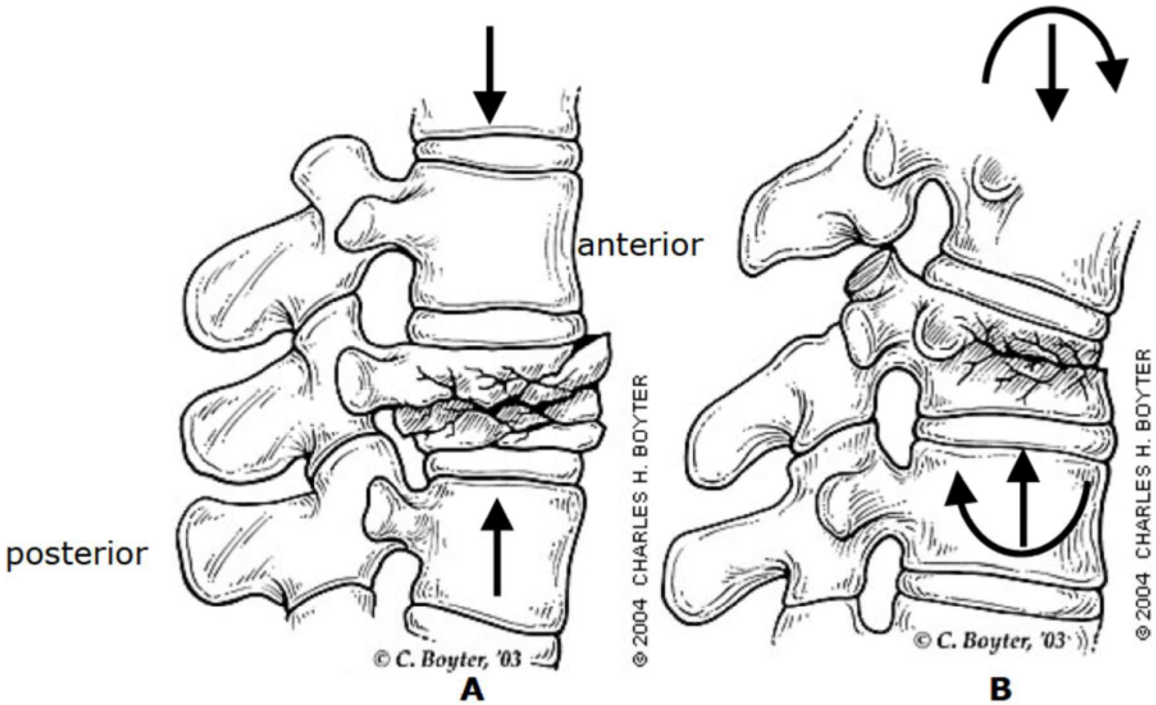

Figure 5. Side view of vertebral burst (A) and anterior wedge fractures (B) with forces typically required to produce the fracture patterns (http://www.aafp.org/afp/2004/0101/p111.html). Note that spine is facing in opposite direction to Figures 2 and 4.

Injury Threshold

Biomechanically, thoracolumbar spinal compression fractures during exposures to vertical loading have been extensively studied for pilots seated in ejection seats (Ewing, 1972). Cadaver data show fractures, in those with a flexed posture, occur at exposures as low as 7g (9.0 ± 2.0g; average age of cadavers 54.3 years) (Ewing, 1972). Furthermore, these studies show that fracture tolerance increases with an erect spine posture (10.4 ± 3.79g; average age of cadavers 61 years), and even more so, with an extended spine posture (17.75 ± 5.55g; average age of cadavers 61.5 years) (Ewing, 1972).

This increase in tolerance in the erect/extended versus flexed spine can be explained biomechanically. Specifically, in the flexed spine, the loading is focused on the anterior (i.e. front) part of the vertebral bodies (Figure 5). But, when the spine is erect/extended, the compressive load is shared between the vertebral bodies and the facet joints located at the back of the spine (Figure 6) and thus increasing the relative tolerance of the spine to compressive loading.

Further thoracolumbar loading studies have tested specimens over different loading conditions, including quasi-statically, over a range of loading rates, at sub-failure and failure levels, and at different levels of spinal flexion (Tushak et al., 2022; Stemper et al., 2017; Stemper et al., 2015). Combined, these data generally suggest very low lumbar spine fracture risk at vertical accelerations of less than 7g.

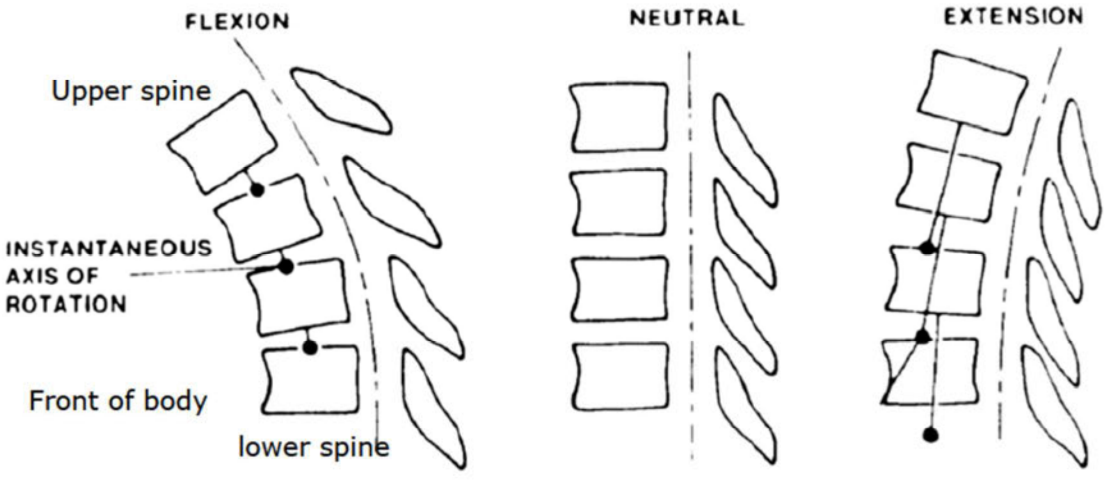

Figure 6. Sagittal cross-section view of the spine in forward flexion, neutral (i.e. erect) and extension (adapted from Panjabi and White, 1980).

Exposure

The public bobsleigh at Whistler Sliding Centre includes vertical exposures of up to 4-4.5g. This exposure is below the 7g shown in the above cadaver data to result in fracture, while in a flexed posture. The spinal loading exposures at the Sliding Centre and the cadaver tests are different, with the peak loading at the Sliding Centre occurring due to the reaction forces at the seat when the bobsleigh is travelling through curve 16. This loading exposure is of longer overall duration than in the cadaver tests, where the loading rate mimics an ejection seat force impulse. The sensitivity of human bone and soft tissue to loading rates and duration may be playing a role in the development of fractures at the Whistler Sliding Centre at loading exposures below that shown to cause fracture in the cadaver specimens subjected to ejection seat loading. Stemper et al., (2012) experimentally demonstrated that lumbar compression fractures migrated distally or lower down the spine in exposures with increased loading rates. The fracture types in the study, burst and anterior compression fractures, did not change with loading rate and are similar to those reported at the Whistler Sliding Centre. Considering the similarity in fracture types, although the loading rates in the bobsleigh are much lower than in Stemper et al (2012), the predominance of L1 or higher fractures following the bobsleigh exposures is generally consistent with Stemper et al.'s (2012) loading rate observations. The potential loading rate effect on vertebral injury tolerance and injury location at rates closer to the Whistler Sliding Centre exposures requires further investigation.

The lower vertical loading exposures at the sliding centre are likely occurring through a different spinal posture than some of the experimental studies noted above, which may also be affecting failure tolerance to the bobsleigh exposures. Within the provided Whistler Sliding Centre injury case information, the majority of the reported low back injuries and spinal fractures occurred in riders positioned in the 4th seat of the bobsleigh. To investigate the potential role of the 4th seating position in the biomechanical causation of the reported thoracolumbar injuries, the 4th seat was analyzed in the context of body and spine position during the seat accelerations developed in Curve 16 (Figures 7 and 8).

Figure 7. Provided images of a typical Whistler Sliding Centre bobsleigh demonstrating the relative positioning of the foot pegs, hand holds, and seating area for the 4th rider/occupant of the bobsleigh.

Figure 8. Provided images of a rider seated in 4th seat of a typical Whistler Sliding Centre bobsleigh, with both feet on the foot pegs and both hands gripping the cable hand holds. Images also show the knees elevated with respect to the hip joints and slight forward curvature/positioning of the upper torso and spine. Upper right image rotated to show consistent alignment.

The following analysis of the 4th seat position in a typical Whistler Sliding Centre bobsleigh is based upon the provided photographs and measurements which were taken by Mr. Ryan Hazlett, PEng, who attended the sliding centre on October 2, 2024. The area of the fourth seat is equipped with foot pegs and cable hand holds for rider support and stabilization during descent (Figure 7). I understand that, in Figure 7, the foot pegs are in their most rearward position but could be positioned slightly forward in another set of anchor holes. The positioning of the hands along the cable hand holds is non-specific and is chosen by the rider.

An exemplar bobsleigh rider/occupant is shown in the fourth seat position with their feet on the foot pegs and hands grasping the cable hand holds in Figure 8. In this self-selected position, the exemplar rider is in an upright or slightly forward flexed seated posture with their thighs elevated above their hips. In a seated posture, the hips are in flexion - about one quarter to one third of hip flexion movement is the consequence of pelvis rotation with this rotation occurring within the first 8 degrees of hip flexion motion (Bohanon et al., 1985). Further hip flexion, as occurs with thigh elevation above the hip joint in a seated posture, further rotates the pelvis leading to an increased curvature of the lower spine and of the upper back. The amount of thigh elevation/hip flexion depends on leg length and the position of the fourth seat relative to the foot pegs. A closer fourth seat position to the foot pegs or longer legs for a rider in the fourth seat is expected to result in greater thigh elevation/hip flexion, greater pelvic rotation, and increased lumbar curvature. Increased lumbar curvature or flexion increases the vulnerability of the lumbar spine and thoracolumbar region to anterior compressive injury when exposed to vertical loading. Similarly, increased forward flexion of the upper torso from an upright seated position in order to reach the cable hand holds, perhaps particularly in someone with relatively shorter arms, would also increase the lumbar curvature and injury risk during a vertical load exposure.

4.3 Rider Injury Factors

Various factors specific to the individual bobsleigh rider could increase their risk for sustaining compression fracture during the Whistler Sliding Centre passenger bobsleigh experience. Generally speaking, these factors include size and strength of the vertebral bodies, pre-existing medical conditions (whether known or unknown to the participant), sex, age, stature, muscle response, and level of muscle strength/endurance. Several factors are addressed in more detail below.

4.3.1 Vertebrae strength

Size and strength of the vertebral bodies can be affected by age and various conditions such as osteoporosis (White and Panjabi, 1990). In general, the vertebral bodies decrease in strength with increasing age (White and Panjabi, 1990) and with osteoporosis (Rajasekaran et al., 2017). Tian et al., (2015) found that the frequency of thoracic, thoracolumbar, and lumbar spine fractures in the elderly were significantly higher than in young adults with an overall median fracture age of 57 years. Bouxsein et al., (2006) reported that vertebral strength specifically declined significantly with aging. A greater decline in vertebral strength was observed in women and was caused by greater decrease in volumetric bone mineral density. It is important to note that Bouxsein et al., (2006) is framed in the context of vertebral fractures being the most common osteoporotic fracture.

Osteoporosis is characterized structurally by low bone mass, with consequent weakening of bone mass and bone architecture. The prevalence of osteoporotic vertebral fractures steadily increases with increasing age and is more common in women than men (Pietschmann et al., 2009). While osteoporotic vertebral fractures can occur over a range of ages, it affects approximately 25% of all postmenopausal women and older men aged greater than 70 years. A majority of osteoporotic fractures occur at the thoracolumbar junction and in the midthoracic region and are usually stable fractures. Additionally, Rajasekaran et al., (2017) report that most fractures truly associated with osteoporosis occur following minor falls, trivial day to day activities, and with no significant trauma.

Similarly, a relationship between rheumatoid arthritis and risk of vertebral fracture has been reported by several observational studies. Rheumatoid arthritis is a chronic and autoimmune joint disease that is associated with subchondral bone and cartilage degradation and progressive bone loss. Osteoporosis is a "silent" complication of rheumatoid arthritis, which may lead to fractures. Of the observational studies suggesting a link between patients with rheumatoid arthritis and an increased risk of vertebral fracture, their small sample size and low level of evidence make the potential relationship less meaningful. However, more recently in their meta-analysis, Chen et al., (2016) demonstrated a significant increase in the risk of vertebral fractures in patients with rheumatoid arthritis. Chen et al., (2016) further concluded that rheumatoid arthritis should be regarded as an independent risk factor of vertebral fracture. Guanabens et al., (2021) noted a similar relationship in postmenopausal women, however, the patients with vertebral fractures generally had more severe rheumatoid arthritis as compared to those without vertebral fractures.

In the cohort of individuals reporting injuries following the bobsleigh experience, there were more women, but only one had a known history of osteoporosis. There was a diagnosis of probable rheumatoid arthritis in a male rider, however, based upon the "probable" qualifier, the disease may not have been at the severe stage associated with vertebral fracture in the above studies. Furthermore, one of the documented fractures occurred in a 37-year-old male, which based solely on age and sex, would be expected to have strong vertebral bodies. Thus, these data suggest that while advancing age, female sex and pre-existing disease causing decreased bony strength may be playing a role here, there are likely other important factors to consider as well.

4.3.2 Stature

Stature and individual anthropometry (i.e. individual body proportions) may be important in injury risk during the bobsleigh experience. Of the individuals with reported spinal fractures for which we have height data, two are 5'10" (one male, one female), one is 5'11" (male), one is 6'3" (male) and one is 5'4" (female). Given that the mean height of men and women in Canada has been reported as 5'9" and 5'3", respectively (Shields et al., 2011), four of these five individuals that sustained fractures would be considered taller than average.

It is my understanding that the Whistler Sliding Centre passenger bobsleigh participants are instructed to maintain grip with the cable hand holds for the duration of the run. Generally speaking, someone of taller stature would adopt a more forward flexed posture than someone of shorter stature, while using the same cable hand hold locations. Furthermore, as discussed above, those with relatively short arms (and long torsos) would have to adopt an even more pronounced flexed spinal posture in order to hold the cables. Also, taller individuals with longer legs may have to flex their knees/hips more in order reach the cable handle holds and in turn would increase their pelvic rotation and lower spine flexion. As previously discussed, a forward flexed spinal posture reduces fracture tolerance. Thus, individuals of taller stature, and in particular those with relatively long leg, long torsos, and short arms, would be at increased risk for fractures due to the spinal forward flexion required for them to reach and maintain grip with the cable hand holds.

4.3.3 <u>Physical strength and endurance</u>

Physical fitness, muscle strength and endurance likely vary in the participants of the passenger bobsleigh experience. It is my understanding that the participants are instructed to maintain a firm grip with both cables, remain upright, shrug their shoulders upwards and outwards in order to support the weight of the helmet and their head and to experience the vertical acceleration compressing then downward into their seats. It is also recommended that the participants wear a "neck brace" to stabilize their posture (Figure 9).

Figure 9. Provided photograph of the "neck brace" recommended for use to stabilize posture.

There was no mention in the reviewed materials as to whether or not any of the participants with back complaints/injuries following the bobsleigh experience were wearing the recommended "neck brace". Review of the various provided photographs and videos (not of the specific incidents of interest) did not show it in use by those featured, possibly suggesting that it is most common to not use the "neck brace".

The physical inability to maintain the suggested upright posture for the duration of the run may alter the loading exposure experienced by a rider and increase an individual's injury risk. It is possible that when the vertical acceleration exposures are largest, towards the end of the run, physical fatigue has set in. This could result in the individual being unable to maintain the suggested posture, such that, for example, further forward spinal flexion occurs. This would place these individuals at higher risk for fracture towards the final curves, which is consistent with where the injuries are reportedly occurring along the track.

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5.0 CONCLUSIONS

1) The understood passenger bobsleigh vertical exposures at the Whistler Sliding Centre of up to 4-4.5g are at the low end of, or below, typical thoracolumbar vertebra fracture tolerances in a flexed posture. The sensitivity of human bone and soft tissue to loading rates and duration may be playing a role in the development of fractures at the Whistler Sliding Centre at these relatively low loading exposures.
2) Individuals of taller stature, and in particular those with relatively long legs, long torsos and short arms, are at increased risk for adopting a posture that would reduce their fracture tolerance during the passenger bobsleigh experience.
3) The above analysis suggests that a flexed posture within the thoracolumbar spine is likely contributing to the spinal fractures diagnosed in riders in the fourth seat following a passenger bobsleigh experience at the Whistler Sliding Centre.
4) The physical inability to maintain the suggested posture for the duration of the bobsleigh run may increase an individual rider's injury risk.
5) Decreased vertebrae strength due to advancing age, female sex and/or pre-existing disease, may play a role in increasing an individual's risk for fracture during the passenger bobsleigh experience.
6) With respect to [redacted], her bone mineral density about 5 months after the incident was reported to be normal (i.e. no osteoporosis), and thus likely did not play a significant role in her injury,
7) [redacted]noted history of probable rheumatoid arthritis was interpreted as being less advanced than the severe rheumatoid arthritis associated with vertebral fractures in the noted studies. Further medical documentation for [redacted] spine including bone mineral density records and pharmaceutical regime is required to confirm whether or not his probable arthritic condition played a role in his injury risk/tolerance, and to what degree, if any.

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Tushak Sk, Donlon JP, Gepner BD, Chebbi A, Pipkorn B, Hallman JJ, Forman JL, Kerrigan JR (2022). Failure tolerance of the human lumbar spine in dynamic combined compression and flexion loading. J Biomech Apr:135:111051. doi: 10.1016/j.jbiomech.2022.111051.

Ursum J, Britsemmer K, van Schaardenburg D et al (2009). High prevalence of vertebral deformities in elderly patients with early rheumatoid arthritis. Annals of the Rheumatic Diseases, Sep;68(9):1512–1513. doi: 10.1136/ard.2008.105957

White AA III and Panjabi MM (1990). Clinical biomechanics of the spine. Second Edition. J.B. Lippincott Company, Philadelphia, PA.

Appendix A- Curriculum Vitae of Dennis D Chimich, MSc, PEng

DENNIS D CHIMICH, MSc PEng
SENIOR BIOMECHANICAL ENGINEER

EDUCATION

Masters of Science, Civil Engineering (Biomechanics), University of Calgary, 1993.
Bachelor of Science, Mechanical Engineering, University of Alberta, 1986.

PROFESSIONAL STATUS

Association of Professional Engineers and Geoscientists of British Columbia (APEGBC), License No. 24645.
Association of Professional Engineers, Geologists & Geophysicists of Alberta (APEGGA), Registration No. M44865
Professional Engineers Ontario, License No. 100126489.

PROFESSIONAL ASSOCIATIONS

American Association of Automotive Medicine (AAAM), since 1998.
Society of Automotive Engineers (SAE), since 1995.

SCHOLARLY ACTIVITIES

Peer-reviews for Traffic Accident Prevention, ASTM Journal of Testing and Evaluation, since 2021.
American Association of Automotive Medicine (AAAM) Scientific Program Committee Member, since 2020.
SAE Transaction Selection Committee Member/Technical Paper Reviewer, since 1995.

EXPERIENCE

MEA FORENSIC ENGINEERS & SCIENTISTS
Senior Biomechanical Engineer, 1999 TO PRESENT
Conducts biomechanical analyses of injury-producing incidents, including assessments of the loads applied to the body, injury mechanics, and the relationship between the applied loads and the injury. Performs seat belt effectiveness analyses to determine the potential for injury with seat belt use. Involved in over 2500 technical investigations related to the biomechanics of injury. Prepares written biomechanical reports and provides expert testimony. Supervises junior biomechanical engineers. Conducts research on biomechanics of injury, low speed collision kinematics, helmet performance and behavior, and slips and falls. Qualified as an Expert Witness in the Supreme Court of British Columbia, the Court of Queen's Bench of Alberta, and the Superior Court of the State of Washington.

SAMAC ENGINEERING LTD., CALGARY, AB
Biomechanical/Mechanical Engineer, 1995 TO 1999
Performed biomechanical analyses of body motion and impact forces during injury causing incidents. Conducted injury probability assessments, injury mechanism analyses, and seat belt effectiveness investigations. Composed biomechanical reports and provided expert testimony in the Court of Queen's Bench of Alberta. Supervised and instructed junior engineers.

TENET MEDICAL ENGINEERING INC., CALGARY, AB
Vice-President, Engineering Operations, 1993 TO 1995
Supervised and coordinated all phases of medical device manufacturing. Performed mechanical design and prototyping of numerous medical devices and instruments for surgery. Conducted research and developed new products. Coordinated and designed protocols for clinical trials and testing. Also wrote grant applications to raise finances for product development.

CONSULTANT, CALGARY, AB
Biomechanical Engineering Consultant, 1988 TO 1995

Provided expertise in medical/legal cases regarding mechanism of soft tissue/bone injury, force analysis and long-term biomechanical effect of injury. Performed mechanical testing on various soft tissues for an orthopaedic research laboratory.

NORTHERN ALBERTA INSTITUTE OF TECHNOLOGY & ALBERTA BUSINESS AND EDUCATIONAL SERVICES, CALGARY, AB
Instructor, 1995
Instructor for biomechanics course in the Orthotics and Prosthetics Technician Program.

THE UNIVERSITY OF CALGARY, FACULTY OF MEDICINE, CALGARY, AB
Instructor, 1991 TO 1994
Taught biomechanics of bone fracture to first year medical students.

THE UNIVERSITY OF CALGARY, MCCAIG CENTRE FOR JOINT INJURY AND ARTHRITIS RESEARCH, CALGARY, AB
Biomechanical Engineer, 1987 TO 1988
Performed and directed the dissection and testing of a variety of soft tissues for a large research team. Contributed to the design, fabrication, testing and use of specialized equipment and instrumentation to measure the structural and material properties of biological tissues. Conducted all phases of testing including data acquisition and reduction, statistical analysis, and writing of scientific manuscripts.

RESEARCH ACTIVITIES

Lead investigator in a study assessing the variability of walkway tribometers.

Co-investigator in a study assessing the effect of contaminant film thickness on tribometer measurements.

Co-investigator in a study investigating the impact performance of helmets at, above and below the test line specified in certification standards.

Co-investigator in a study investigating tribometer performance for slip and fall investigations.

Co-investigator in a study investigating the impact performance of various types of used bicycle helmets.

Lead investigator in a study investigating the relationship between motorcycle helmet damage and impact severity.

Co-investigator in a study assessing bathtub slip and fall during entrance and exit.

Co-investigator in a study comparing the impact performance of various types of motorcycle helmets.

Co-investigator in a study to assess the effect of seatbelt usage during airbag deployment and the risk for brain injury in frontal collisions.

Co-investigator in a study to quantify the relationship between vehicle damage and the potential for neck injury in 20 common vehicles in the BC fleet.

Co-investigator in a study of the effect of seat belt slack and anchor location on the head and lower limb excursion of crash test dummies in frontal collisions.

Co-investigator in a parametric study on the effect of collision pulse shape on the kinematic response of anthropomorphic test dummies in low speed rear end impacts.

Co-investigator in a study of the effect of head restraint placement and seat back stiffness on the kinematic and kinetic response of anthropomorphic test dummies in low speed rear end impacts.

Co-investigator in a study on the response of anthropomorphic test dummies vs human volunteers in low speed rear end impacts.

PUBLICATIONS

PEER-REVIEWED JOURNALS

Chimich DD, Al-Salehi L, Elkin BS, Siegmund GP (2022). Contaminant film thickness affects walkway friction measurements. Frontiers in Public Health, Occupational Health and Safety. 10:915140. doi: 10.3389/fpubh.2022.915140.

Siegmund GP, Blanchette MG, Brault JR, Chimich DD, Elkin BS (2021). Quantifying the uncertainty in tribometer measurements on walkway surfaces. Ergonomics 64(3), pp. 396-409. doi: 10.1080/00140139.2020.1797182.

Chimich DD, Elkin BS, Siegmund GP (2020). Variability of friction measurements using three common walkway tribometers. Journal of Testing and Evaluation, 49(5), JTE20190637. doi: 10.1520/JTE20190637.

DeMarco AL, Chimich DD, Bonin SJ, Siegmund GP (2020). Impact performance of certified bicycle helmets below, on and above the test line. Annals of Biomedical Engineering, 48(1), pp. 58-67. doi: 10.1007/s10439-019-02422-x.

DeMarco AL, Good CA, Chimich DD, Bakal JA, Siegmund GP (2017). Age has a minimal effect on the impact performance of field-used bicycle helmets. Annals of Biomedical Engineering, 45(8), pp. 1974-1984. doi: 10.1007/s10439-017-1842-4.

DeMarco AL, Chimich DD, Gardiner JC, Siegmund GP (2016). The impact response of traditional and BMX-style bicycle helmets at different impact severities. Accident Analysis and Prevention, 92, pp. 175-183.

DeMarco AL, Chimich DD, Gardiner JC, Nightingale RW, Siegmund GP (2010). The impact response of motorcycle helmets at different impact severities. Accident Analysis and Prevention, 42(6), 1778-84.

Siegmund GP, Flynn J, Mang DW, Chimich DD, Gardiner JC (2010). Utilized friction when entering and exiting a dry and wet bathtub. Gait & Posture Gait & Posture, 31(4), 473-478.

Siegmund GP, Heinrichs BE, Chimich DD, Lawrence JM (2005). Variability in vehicle and dummy responses in rear-end collisions. Traffic Injury Prevention, 6, pp. 267-277.

Siegmund GP, Chimich DD, Heinrichs BE, DeMarco AL, Brault JR (2005). Variations in occupant responses to moderate frontal impacts vary with seat belt slack and anchor location. Traffic Injury Prevention, 6(1), pp. 38-43.

Siegmund GP, Heinrichs BE, Chimich DD, DeMarco AL, Brault JR (2005). The effect of collision pulse properties on seven proposed whiplash injury criteria. Accident Analysis and Prevention, 37(2), pp. 275-285.

Siegmund GP, Brault JR, Chimich DD (2002). Do cervical muscles play a role in whiplash injury? Journal of Whiplash & Related Disorders, 1, pp. 23-40.

Shrive N, Chimich DD, Marchuk L, Wilson J, Brant R, Frank C (1995). Soft tissue "flaws" are associated with the material properties of the healing rabbit medial collateral ligament. Journal of Orthopaedic Research, 13(6), pp. 923-929.

Frank C, Loitz B, Bray R, Chimich DD, King G, Shrive N (1994). Abnormality of the contralateral ligament after injuries of the medial collateral ligament. An experimental study in rabbits. Journal of Bone and Joint Surgery, 76(3), pp. 403-412.

Chimich DD, Frank C, Shrive N, Bray R, King G, McDonald D (1993). No effect of mop-ending on ligament healing: Rabbit studies of severed collateral knee ligaments. Acta Orthopaedica Scandinavica, 64(5), pp. 587-591.

Chimich DD, Shrive N, Frank C, Marchuk L, Bray R (1992). Water content alters viscoelastic behaviour of the normal adolescent rabbit medial collateral ligament. Journal of Biomechanics, 25(8), pp. 831-837.

Frank C, McDonald D, Bray D, Rangayyan R, Chimich DD, Shrive N (1992). Collagen fibril diameters in the healing adult rabbit medial collateral ligament. Connective Tissue Research, 27(4), pp. 251-263.

Bray R, Shrive N, Frank C, Chimich DD (1992). The early effects of joint immobilization on medial collateral ligament healing in an ACL-deficient knee: A gross anatomic and biomechanical investigation in the adult rabbit model. Journal of Orthopaedic Research, 10(2), pp. 157-166.

Chimich DD, Frank C, Shrive N, Dougall H, Bray R (1991). The effects of initial end contact on medial collateral ligament healing: A morphological and biomechanical study in a rabbit model. Journal of Orthopaedic Research, 9(1), pp. 37-47.

PEER-REVIEWED CONFERENCE PROCEEDING

DeMarco AL, Chimich DD, Bonin SJ, Siegmund GP (2018). Substandard impact performance of common bicycle helmets. Brain Injury Across the Age Spectrum: Improving Outcomes for Children and Adults Conference, The Journal of Head Trauma Rehabilitation, 33(3), pp. E87-E88. doi:10.1097/HTR.0000000000000401.

BOOK CHAPTERS

Siegmund GP, Chimich DD, Elkin BS (2015). The role of muscle in accidental injury. In: N Yoganandan, AM Nahum, JW Melvin (Eds), Accidental Injury: Biomechanics and Prevention, 3rd Ed., pp. 611-642. Springer, New York.

ABSTRACTS, POSTER PRESENTATIONS

Chimich DD, Rutledge BA, Elkin BS, Siegmund GP (2018). Variability of walkway tribometers. 8th World Congress of Biomechanics: Dublin, Ireland, July 8-12, 2018.

Rutledge BA, Chimich DD, Elkin BS, Siegmund GP (2018). The effect of contaminant film thickness on slip resistance. 8th World Congress of Biomechanics: Dublin, Ireland, July 8-12, 2018.

DeMarco AL, Chimich DD, Elkin BS, Siegmund GP (2018). Standard impact performance of common bicycle helmets. North American Brain Injury Society (NABIS) Conference, Houston TX, March 14-17, 2018.

Rutledge BA, Elkin BS, Chimich DD, Siegmund GP (2017). Effect of contaminant film thickness on tribometer measurements. Panel Session 3: Current Issues in Tribometer Use and Validity. Slips, Trips, and Falls International Conference 2017, Toronto, ON.

Rutledge B, Elkin B, Chimich DD, Siegmund G (2017). Film thickness and other factors that affect tribometer measurements. ASTM Workshop on Multifactorial Analysis of Slip and Fall Events: Implications for Forensic and Safety Professionals. West Conshohocken, PA, January 30, 2017.

Nelson TS, Gardiner, JC, Chimich DD, Siegmund GP (2015). Head, neck, chest, and lumbar responses during compact SUV rollovers. 43rd International Workshop on Human Subjects in Biomechanics Research, New Orleans, LA, November 8, 2015.

Chimich DD, DeMarco AL, Siegmund GP (2014). Motorcycle helmet crush and impact behavior depends on impact surface shape. 7th World Congress of Biomechanics, Boston, MA, July 6-11, 2014.

DeMarco AL, Good CA, Chimich DD, Bakal JA, Siegmund GP (2014). The effect of age on bicycle helmet impact attenuation. 7th World Congress of Biomechanics, Boston, MA, July 6-11, 2014.

Chimich DD, DeMarco AL, Siegmund GP (2012). Motorcycle helmet impact behavior depends on impact surface shape. 40th International Workshop on Human Subjects in Biomechanics Research, Savannah, GA, October 28, 2012.

DeMarco AL, Kam CY, Chimich DD, Siegmund GP (2012). Bicycle helmet performance over a wide range of impact speeds. Canadian Society of Biomechanics 17th Biennial Meeting, Vancouver, BC, June 6-9, 2012.

DeMarco AL, Chimich DD, Gardiner JC, Nightingale RW, Siegmund GP (2006). Motorcycle helmet impact response: Comparison of helmet type and impact severity. Presented at the 34th International Workshop on Human Subjects in Biomechanics Research, Dearborn, MI, November 5, 2006.

DeMarco AL, Chimich DD, Siegmund GP (2006). Brain injuries and airbags: The effect of a seatbelt (BIO2006-157544). ASME 2006 Summer Bioengineering Conference, Amelia Island, FL, June 21-25, 2006.

Brault JR, Gardiner JC, Chimich DD, Siegmund GP (2004). Biomechanical determinants of injuries from low-level falls. 56th Annual Meeting of the American Academy of Forensic Sciences, Dallas, TX, February 16-21, 2004.

Siegmund GP, Chimich DD, Heinrichs BE, DeMarco AL, Brault JR (2003). Occupant response during moderate frontal impacts varies with seat belt slack and anchor location. Presented at the 31st International Workshop on Human Subjects in Biomechanics Research, San Diego, CA, October 26, 2003.

Siegmund GP, Heinrichs BE, Chimich DD, DeMarco AL, Brault JR (2002). The effect of collision pulse properties on whiplash kinematics and kinetics. In: Proc of 30th International Workshop on Human Subjects in Biomechanical Research. Washington DC: US Department of Transportation, National Highway Traffic Safety Administration, November 9, 2002.

Chimich DD, Heinrichs BE, Brault JR, DeMarco AL, Siegmund GP (2002). Head restraint position affects occupant response in rear-end collisions. Fourth World Congress of Biomechanics, Calgary, AB, August 4-9, 2002.

Chimich DD, Shrive N, Frank C (May 1993). In-vitro simulation of clinically relevant anterior cruciate ligament failure mechanisms. Canadian Orthopaedic Research Society, Montreal, QC.

Chimich DD, McPherson R, Roux L, Shrive N, Frank C (June 1991). Comparison of the biomechanical properties of single and double frozen human bone-patellar ligament-bone complexes. Canadian Orthopaedic Research Society, Calgary, AB.

Bray R, Frank C, Shrive N, Chimich DD (1991). The early effects of joint immobilization on ACL-deficient medial collateral ligament healing in the adult rabbit model. Orthopaedic Research Society Transactions 16, pg 135.

Frank C, Shrive N, Chimich DD, Bray R, Leask G, Edwards H, King G (1991). The effect of surface area and gap size on medial collateral ligament healing. Orthopaedic Research Society Transactions 16, pg 138.

Chimich DD, Bray R, Frank C, Shrive N (June 1990). Contralateral knee ligaments may not be "normal" after opposite knee surgery: A biomechanical study in the adult rabbit MCL complex. Canadian Orthopaedic Research Society, Vancouver, BC.

McPherson R, McAllister D, Chimich DD, Shrive N, Schachar N (1990). A comparison of confined and unconfined compression testing of articular cartilage: Sensitivity and variability. Orthopaedic Research Society Transactions 15, pg 154.

Bray R, Frank C, Shrive N, Chimich DD, Hennenfent B (1990). Joint instability alters scar quantity and quality in a healing rabbit ligament. Orthopaedic Research Society Transactions 15, pg 58.

McPherson R, McAllister D, Chimich DD, Shrive N, Schachar N (May 1989). A comparison of confined and unconfined compression testing of articular cartilage: Sensitivity and variability. Canadian Orthopaedic Research Society, Toronto, ON.

Chimich DD, Marchuk L, Bray R, Sterenberg D, Frank C, Shrive N (May 1989). Water content influences ligament viscoelastic behaviour. Canadian Orthopaedic Research Society, Toronto, ON.

Chimich DD, Frank C, Shrive N, Dougall H, Bray R (May 1989). The biomechanical effects of torn end contact on medial collateral healing. Canadian Orthopaedic Research Society, Toronto, ON.

McPherson R, Shrive N, Chimich DD, McAllister D, Schachar N (1989). Filter pore size distribution and porosity affect stress relaxation behaviour in bovine articular cartilage. Orthopaedic Research Society Transactions 14, pg 147.

Walsh S, Frank C, Chimich DD, Lam T, Hart D (1989). Immobilization inhibits biomechanical maturation of growing ligaments. Orthopaedic Research Society Transactions 14, pg 253.

OTHER PUBLICATIONS

Chimich DD (2014). Predicting Motorcycle Helmet Impact Severity from Liner Crush Damage, The Continuing Legal Education Society of British Columbia.

DeMarco AL, Gardiner JC, Chimich DD (2012). The Biomechanics of Head Injury Causation and Prevention. Claims, Biomechanics and Bodily Injury.

Chimich DD and DeMarco AL (2010). Injury Biomechanics in Sports and Recreation Cases. The Verdict, Winter 10, 123, pp. 47-50.

Chimich DD (2006). Injury biomechanics and soft tissue injuries. The Continuing Legal Education Society of British Columbia.

Chimich DD (2006). Effects of head restraint on occupant response in rear-end collisions. The Continuing Legal Education Society of British Columbia.

Chimich DD, Siegmund GP (2003). Injury biomechanics: A tool for personal injury cases. Canadian Insurance, October, pp 40-42, Stone & Cox Limited Publications, Toronto, ON.

Chimich DD (1997). Biomechanics – Application to low speed collisions. The Barrister, 44, pp12-21. Alberta Civil Trial Lawyers Association, Edmonton, AB.

Chimich DD (1993). Design and implementation of a method for structural testing of knee joints. Masters Thesis, Department of Civil Engineering, The University of Calgary, Calgary, AB.

LECTURES AND PRESENTATIONS

Hundreds of presentations on the biomechanics of injury have been made to law firms and insurance companies. Presentations have been provided throughout British Columbia, Alberta, and Washington State. Below are several invited presentations for legal, medical, and insurance societies.

Pending - June 24, 2024 – Expert Evidence in Workplace Fatality Cases, Workplace Fatality Cases 2024, Continuing Legal Education Society of British Columbia (CLEBC), virtual.

Feburary 2, 2023 – Injury Biomechanics, Canadian Bar Association (Alberta - South), Personal Injury Section, Virtual.

June 30, 2020 – USC3 Tile Testing, ASTM F13 Committee Meeting, Virtual meeting.

November 1, 2016 – Injury Biomechanics in Property and Product Liability Cases, The Canadian Bar Association, Insurance Law Section (North), Edmonton, AB.

January 23, 2014 – Co-chair and presenter – Effective Use of Injury Biomechanics, Engineering Evidence in Civil Litigation, Continuing Legal Education Society of British Columbia (CLEBC), Vancouver, BC.

October 17, 2012 – Biomechanical Analysis and Injury Assessment, Medical Issues in Personal injury, Continuing Legal Education Society of British Columbia (CLEBC), Vancouver, BC.

May 10, 2012 – Injury Biomechanics, Canadian Defence Lawyers Boot Camp II, Vancouver, BC.

May 19, 2011 – Injury Biomechanics, Canadian Defence Lawyers Boot Camp, Vancouver, BC.

October 15, 2010 – Motorcycle Helmet Effectiveness, Personal Injury Conference, Continuing Legal Education Society of British Columbia (CLEBC), Vancouver, BC.

June 10, 2010 – Pedestrian and Bicycle Accidents: Injury Based Biomechanical Analyses, Canadian Defence Lawyers Audio Conference, Vancouver, BC.

May 6, 2010 – Injury Biomechanics, Canadian Defence Lawyers Boot Camp, Vancouver, BC.

March 10, 2010 – June 27, 2012 – Slip, Trip and Fall, Insurance Institute of British Columbia (IIBC), Vancouver, Victoria, Kelowna, Kamloops BC.

June 23, 2009 – Biomechanics of the Slip, Trip & Fall, Teleseminar & Powerpoint Presentation, Trial Lawyers Association of BC, Vancouver, BC.

April 2008 – Injury Biomechanics. Canadian Defence Lawyers Boot Camp II, Vancouver, BC.

December 07, 2006 – Injury biomechanics and soft tissue injuries. Medical Issues in Personal Injury Conference, The Continuing Legal Education Society of British Columbia, Vancouver, BC.

June 02, 2006 – Effects of head restraint position on occupant response in rear-end collisions. Personal Injury Conference, The Continuing Legal Education Society of British Columbia, Vancouver, BC.

September 19, 2002 – Injury biomechanics, Washington Association of Independent Medical Examiners, Seattle, WA.

April 24, 2002 – Injury biomechanics, Washington Defense Trial Lawyers, Seattle, WA.

August 15, 2001 – The biomechanics of cervical spine fractures. The Fourth International Conference on Accident Investigation, Reconstruction, Interpretation and the Law, Vancouver, BC.

October 26, 2000 – The biomechanics of injury, Lindsay Kenney Insurance Law Seminar, Vancouver, BC.

September 27-28, 1997 – Vehicle and biomechanical analysis of low speed collisions, Whiplash seminar, The College of Chiropractors of Alberta, Calgary, AB.

April 25, 1996 – Biomechanics of injury and low speed collisions, The low speed package, sponsored by The Insurance Institute of Southern Alberta, Calgary, AB.

April 2, 1996 – Low speed impact investigation and biomechanics of injury, Personal injury section of the Alberta Branch of the Canadian Bar Association, Calgary, AB.

TRAINING AND PROFESSIONAL DEVELOPMENT

September 11-13, 2024 – International Research Council on Biomechanics of Injury (IRCOBI) Conference, Stockholm, Sweden.

September 10, 2024 – Tissue based head injury criteria and risk curves for virtual assessment, Stockholm, Sweden.

January 24-25, 2022 – ASTM Standards Development Meeting of Committee F13 – Pedestrian/Walkway Safety and Footwear, Online.

October 26-27, 2021 – 49th NHTSA International Workshop on Human Subjects for Biomechanical Research, Online.

September 16, 2021 – Preventing slips, trips, and falls in the workplace, IEA Slip, Trip, and Fall Technical Committee Webinar, Online.

June 13-18, 2021 – 21st IEA Triennial Congress, Online.

March 22-25, 2021 – iNPUT-ACE Video Evidence Symposium 2021, Online.

February 2, 2021 – Footwear ASTM F13 Research Subcommittee Meeting, Online.

October 27-28, 2020 – 48th NHTSA International Workshop on Human Subjects for Biomechanical Research, Online.

July 30, 2020 – Pedestrian walking safety and posture, ASTM F-13 Research, Subcommittee Meeting, Online.

December 15, 2020 – Behind the scenes look at an Insurance Institute of Highway Safety (IIHS) crash test, Association for the Advancement of Automotive Medicine, Webinar.

January 9-March 26, 2020 – BLDC 1500 - Building Code: Part 9 (SFD), British Columbia Institute of Technology.

September 11-13, 2019 – International Research Conference on Biomechanics of Injury Conference, Florence, Italy.

February 5, 2019 – Building Smart with 2018 BC Building Code Changes – Vancouver, Seminar, BC Housing Webinar.

July 8-12, 2018 – 8th World Congress of Biomechanics, Dublin, Ireland.

June 25, 2018 – ASTM Standards Development Meeting of Committee F13 – Pedestrian/Walkway Safety and Footwear, San Diego, CA.

February 2, 2018 – AIS Analysis Tips and Tricks for Proper Use, Association for the Advancement of Automotive Medicine, Webinar.

January 22, 2018 – ASTM Standards Development Meeting of Committee F13 – Pedestrian/Walkway Safety and Footwear, New Orleans, LA.

June 15-16, 2017 – Slips, Trips, and Falls International Conference 2017, Toronto, ON.

January 31, 2017 – ASTM Standards Development Meeting of Committee F13 – Pedestrian/Walkway Safety and Footwear, West Conshohocken, PA.

January 30, 2017 – Workshop on Multifactorial Analysis of Slip and Fall Events: Implications for Forensic and Safety Professionals. West Conshohocken, PA.

November 7-9, 2016 – 60th Stapp Car Crash Conference, Washington DC.

November 9-11, 2015 – 59th Stapp Car Crash Conference, New Orleans, LA.

November 8, 2015 – 43rd International Workshop on Human Subjects for Biomechanical Research, New Orleans, LA.

July 6, 2015 – Ontario Building Code Part 9: An Overview, Ontario Society of Professional Engineers, Mississauga, ON.

November 10-12, 2014 – 58th Stapp Car Crash Conference, San Diego, CA.

November 9, 2014 – 42nd International Workshop on Human Subjects for Biomechanical Research, San Diego, CA.

July 6-11, 2014 – 7th World Congress of Biomechanics, Boston, MA.

November 11-13, 2013 – 57th Stapp Car Crash Conference, Orlando, FL.

November 10, 2013 – 41st International Workshop on Human Subjects for Biomechanical Research, Orlando, FL.

October 29-31, 2012 – 56th Stapp Car Crash Conference, Savannah, GA.

October 28, 2012 – 40th International Workshop on Human Subjects for Biomechanical Research, Savannah, GA.

July 12, 2012 – The Pathophysiology of Traumatic Brain Injury Conference, Vancouver, BC.

June 7-9, 2012 – Canadian Society of Biomechanics 17th Biannual Meeting, Vancouver BC.

June 6-9, 2012 – 17th Biennial Conference Canadian Society for Biomechanics (CSB-SCB), Vancouver, BC.

November 3-5, 2010 – 54th Stapp Car Crash Conference, Scottsdale, AZ.

November 2, 2010 – 38th International Workshop on Human Subjects for Biomechanical Research, Scottsdale AZ.

November 2-4, 2009 – 53rd Stapp Car Crash Conference, Savannah, GA.

November 3-5, 2008 – 52nd Stapp Car Crash Conference, San Antonio, TX.

November 2, 2008 – 36th International Workshop on Human Subjects for Biomechanical Research, San Antonio, TX.

October 29-31, 2007 – 51st Stapp Car Crash Conference, San Diego, CA.

October 28, 2007 – 35th International Workshop on Human Subjects for Biomechanical Research, San Diego, CA.

June 6, 2006 – Tribometer Workshop, Sponsored by the ASTM Committee F-13 on Pedestrian/Walkway Safety and Footwear, Pasadena CA.

November 9-11, 2005 – 49th Stapp Car Crash Conference, Washington, DC.

November 8, 2005 – 33rd International Workshop on Human Subjects for Biomechanical Research, Washington, DC.

November 1-3, 2004 – 48th Stapp Car Crash Conference, Nashville, TN.

October 31, 2004 – 32nd International Workshop on Human Subjects for Biomechanical Research, Nashville, TN.

October 27-29, 2003 – 47th Stapp Car Crash Conference, San Diego, CA.

October 26, 2003 – 31st International Workshop on Human Subjects for Biomechanical Research, San Diego, CA.

October 9-10, 2003 – International Whiplash Trauma Congress, Denver, CO.

June 29, 2003 – Tribometer Workshop, sponsored by the ASTM Committee F-13 on Pedestrian/Walkway Safety and Footwear, Pasadena, CA.

June 28, 2003 – Symposium on the Biomechanics of Slip and Fall, sponsored by the ASTM Committee F-13 on Pedestrian/Walkway Safety and Footwear, Pasadena, CA.

November 11-13, 2002 – 46th STAPP Car Crash Conference, Ponte Vedra Beach, FL.

November 10, 2002 – 30th International Workshop on Human Subjects for Biomechanical Research, Ponte Vedra Beach, FL.

August 4-9, 2002 – 4th World Congress of Biomechanics, Calgary, AB.

November 6-8, 2000 – 44th STAPP Car Crash Conference, Atlanta, GA.

November 4-5, 2000 – Clinical and Biomechanical Aspects of Lower Extremity Injuries, Wayne State University, School of Medicine, Atlanta, GA.

October 25-27, 1999 – 43rd STAPP Car Crash Conference, San Diego, CA.

October 24, 1999 – 27th International Workshop on Human Subjects for Biomechanical Research, San Diego, CA.

August 8-13, 1999 – International Society of Biomechanics XVIIth Congress, Calgary AB.

February 7-11, 1999 – World Congress on Whiplash-Associated Disorders, Vancouver, BC.

November 5-6, 1998 – Whiplash 98, SAE, Tempe, AZ.

November 2-4, 1998 – 42nd STAPP Car Crash Conference, SAE, Tempe, AZ.

November 15, 1997 – 25th International Workshop in Human Subjects for Biomechanical Research, Lake Buena Vista, FL.

November 13-14, 1997 – 41st STAPP Car Crash Conference, SAE, Orlando, FL.

November 12, 1997 – 2nd Child Occupant Protection Symposium, SAE, Orlando, FL.

November 10-11, 1997 – 41st Association for the Advancement of Automotive Medicine Conference, Orlando, FL.

August 14-15, 1997 – Airbag Design and Performance TOPTEC Workshop, SAE, Costa Mesa, CA.

November 7-8, 1996 – AGARD Specialists' Meeting, NATO, Impact Head Injury, Mescalero, NM.

November 4-6, 1996 – 40th STAPP Car Crash Conference, SAE, Albuquerque, NM.

November 3, 1996 – 24th International Workshop on Human Subjects for Biomechanical Research, Albuquerque, NM.

August 19-20, 1996 – Low Speed Collision TOPTEC Workshop, SAE, Vancouver, BC.

November 11-12, 1995 – Accidental Injury: Biomechanics & Prevention, University of California at San Diego, School of Medicine, San Diego, CA.

November 8-10, 1995 – 39th STAPP Car Crash Conference, SAE, San Diego, CA.

Numerous Canadian and International orthopedic research conferences have been attended since 1988.

*10/30/24

Appendix B- List of Materials Reviewed

The following materials were reviewed in preparation of this report:

- Email from Ryan Hazlett, dated September 2, 2024;
- 2022-23 Bobsleigh Presentation-new images small, undated;
- KnowBeforeYouGo_PassengerBobsleigh_Winter23-24, undated;
- Waiver - [redacted], undated;
- WSC SafetyVideo-SHORT, undated;
- Biomechanics of Osteoporosis and Vertebral.5, dated 1997;
- Dr. Warburton G Force Summary (Skeleton only), dated January 26, 2011;
- Spinal Fractures in Recreational Bobsledders an unexpected mechanism of injury, dated May 2012;
- Stuart et al. - 2016 - Injuries at the Whistler Sliding Center a 4-year, dated 2016;
- Whistler Sliding Centre Sled Trajectory and Track Construction Study, dated 2012;
- Discharge Summary [redacted], dated February 10, 2024;
- NeuroSX Bill [redacted],dated February 27, 2024;
- Request for Medical Records – [redacted]– Signed, dated February 21, 2024;
- [redacted] -Ambulance Invoice, dated March 27, 2024;
- VCH Invoice, dated March 12, 2024;
- Email from IncidentNotification@technicalsafetybc.ca, dated February 15, 2024;
- Medical Release [redacted], dated February 21, 2024;
- Notes from Interview with [redacted], dated February 12, 2024;
- [redacted] First Aid Record, dated February 9, 2024;
- [redacted] Waivers, dated February 9, 2024;
- 127 SEP CORP [redacted], dated November 11, 2022;
- 127_SEP CORP [redacted]_2023.11.22-2023-11-23 12.14.59.378 PM, undated;
- Quotes from Interview with [redacted], undated;
- Clinical Info 7b46fc3e-edc7-ee11-a96d-005056aa1fb3, undated;
- Clinical Info 83f528d3-33c8-ee11-a96d-005056aa1fb3, undated;
- Clinical Info 88f528d3-33c8-ee11-a96d-005056aa1fb3, undated;
- Clinical Info 0298c9f4-f1c7-ee11-a96d-005056aa1fb3, undated;
- Report 7b46fc3e-edc7-ee11-a96d-005056aa1fb3, dated February 10, 2024;
- Report 83f528d3-33c8-ee11-a96d-005056aa1fb3, dated February 10, 2024;
- Report 88f528d3-33c8-ee11-a96d-005056aa1fb3, dated February 10, 2024;
- Report 0298c9f4-f1c7-ee11-a96d-005056aa1fb3, dated February 10, 2024;
- Imaging Reports with Disc, dated February 27, 2024;
- DICOM Images, dated February 10, 2024;
- Imaging Reports with Disc, dated February 27, 2024;
- [redacted] chart, dated November 23, 2024 to 24 July 2024;
- 127 SEP CORP [redacted]2023.11.22 – Runsheet, dated November 22, 2023;
- 127_SEP CORP [redacted]_2023.11.22-2023-11-23 12.14.59.378, undated;
- Quotes from Interview with [redacted], undated;
- Call with [redacted] (No osteoporosis), dated May 3, 2024.