AAAM 68th Annual Conference Student Symposium Abstracts

November 11-14, 2024
Seoul, South Korea

E-scooter Rider Average Positioning Investigation for Biomechanical Research

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INTRODUCTION

The popularity of e-scooters in urban areas is growing rapidly. In the United States, for example, the number of shared trips increased by 50% between 2018 and 2022, reaching 60 million (NACTO 2022). At the same time, injuries related to these personal mobility vehicles increased by 250% over the same period and in the same country (CPDS 2022). Furthermore, when comparing the e-scooter data in NACTO 2021 and NTSB 2022 to the motor vehicle data in NHTSA 2021, the e-scooter was 700 times more injurious and 30 times more fatal per mile traveled than the motor vehicle in the United States in 2021. As a result, concern related to the safety of e-scooters is growing among citizens and organizations alike, as evidenced by their ban in Paris following a referendum or their inclusion in the recent World Health Organization (WHO) 2023 Road Safety Report. Therefore, it is crucial to study the injury mechanisms of e-scooter incidents from a biomechanical standpoint.

This study aims to define the average global rider positioning in relation to gender, height and weight. To this end, a naturalistic study was conducted with 84 volunteers in a controlled environment, and the positioning of 16 landmark points was recorded and analyzed. Understanding the average rider position is critical as it represents a key aspect of the e-scooter collision boundary conditions that must be thoroughly investigated to enable effective experimental or simulation testing.

METHODS

Volunteer Test and Data Acquisition

A total of 84 volunteers, 54 males and 30 females, ranging in age from 17 to 65 years, participated. Both institutional data protection policies and ethical standards were followed. Prior to the tests, the volunteers completed a questionnaire regarding gender, age, physical characteristics (height, weight and dominant leg), previous experience with e-scooters and purpose of use, frequent modes of transportation, perception of safety of e-scooters and helmet use, and subsequent informed consent.

The test consisted of an 8600 square foot, multi-way signposted track (Figure 1) built in a controlled environment and equipped with four Dott e-scooters (with a top speed of 15.5 mph). All volunteers were offered an open face helmet. Three of the e-scooters were designed as dummies with the purpose of generating traffic and, therefore, an environment with an impact on the riders as close as possible to that of a real urban scenario. The fourth e-scooter was defined as the target rider and was given the opportunity to stay on the track for an unlimited period of time.

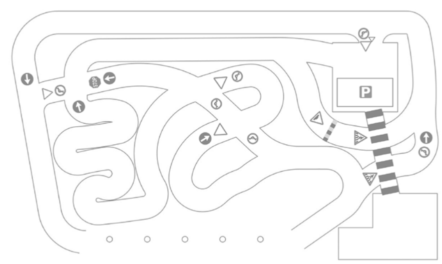

Figure 1: Drawing of Volunteer Testing Track

An outboard camera was positioned to capture the global position of all target riders during the longest straightaway on the track. This was conducted after the target rider had become familiar with the track. In addition, two onboard cameras were installed on all target riders. The first one captured a video of the positioning of the feet with respect to the deck of the e-scooter. The second one captured the position of the e-scooter relative to the track, in order to synchronize a foot positioning frame with the global positioning image. Figure 2 shows an example of the output from the three cameras (one example frame is provided for each of the onboard cameras).

Data Analysis and 3D Positioning Calculation

16 anatomical landmarks were selected based on ease of differentiation in the output data and completeness of definition of global rider positioning: right and left foot tip and heel, right and left lateral malleolus, right and left patella, midpoint of the line joining the iliac crests, right and left radius styloid process, right and left humerus lateral condyle, right and left acromion, and midpoint of the line joining the two tragi.

Figure 2: Camera Output Examples

To analyze the data obtained, the representativeness of the sample was evaluated by comparing physical characteristics with NHANES 2011-2014 database. Subsequently, foot positioning configurations and their relationship to the dominant leg were qualitatively analyzed.

The camera outputs were then examined. First, the foot positioning frame of the onboard foot camera was selected to match the track point of the outboard camera image. Second, both images were corrected for vanishing point and lens distortion using reference lines from the track and known camera parameters, and the pixel-to-mm ratio was calibrated for all axes using known dimensions. Finally, 2D landmark points were manually selected (XY and XZ coordinates for the outboard and onboard cameras, respectively, following a dextrorotatory coordinate system).

Several assumptions and simplifications were made to obtain the 3D coordinates from the original 2D data. First, both the tragus and iliac crest midpoints were assumed to be contained within the sagittal plane. Second, the wrists, elbows, and shoulders were simplified to be symmetrical in the sagittal plane. Third, the anthropometric distribution of each subject was assumed to be equivalent to that of the NHANES database for the same gender, height, and weight.

RESULTS

Sample Quality and Qualitative Analysis

Figure 3 shows a comparison of the distribution of age and body mass index (BMI) between the subjects and the NHANES 2011-2014 database (17 to 65 years) to assess the anthropometric representativeness of the sample. The obtained Cohen's d values for age, and male and female BMI were 0.84, 0.63, and 0.89, respectively.

Figure 4 shows the distribution of foot positioning configurations grouped into four types: parallel feet, left foot forward, right foot forward, one foot outboard, and unclassifiable; and a comparison of these configurations with the dominant leg of the subjects. 56% of all subjects used the right foot forward, followed by the left foot forward with 26%. 94% of the sample was right leg dominant.

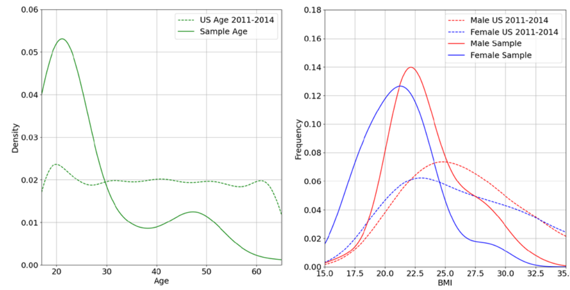

Figure 3: Sample vs NHANES 2011-2014 Database Age and BMI Distribution Comparison

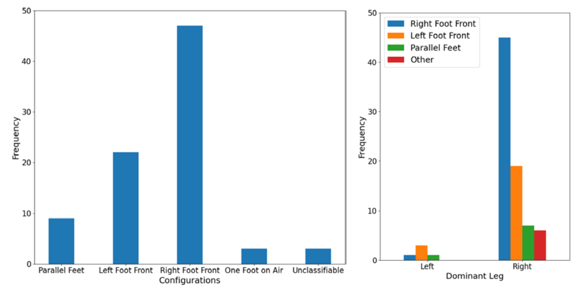

Figure 4: Foot Positioning Configurations and Comparison Against Dominant Leg

3D Positioning

Figure 5 shows three orthogonal views of the 16 anatomical landmarks of the subjects of the experiment. Absolute values in mm are provided. In addition, 95% confidence intervals are shown by 3D ellipsoids, except for the tragus and iliac crest midpoints, which are shown by 2D ellipsoids, since they are contained within the sagittal plane.

DISCUSSION

The Cohen's d values calculated to evaluate the quality of the sample indicate that the study sample means are notably higher than the database for the parameters analyzed. When both samples were reduced to ages 17 to 30, the Cohen's d values were 0.14, 0.40, and 0.70, respectively, suggesting a study sample significantly younger than the database and a large effect of age on BMI measures.

In terms of foot positioning configurations, the use of the right foot forward was predominant. Furthermore, 7% of the riders constantly changed their position or had one foot outside the deck, unstable configurations that could increase the likelihood of falling off the e-scooter. Only 5 users were left leg dominant, reducing any possible conclusions to right leg dominant users.

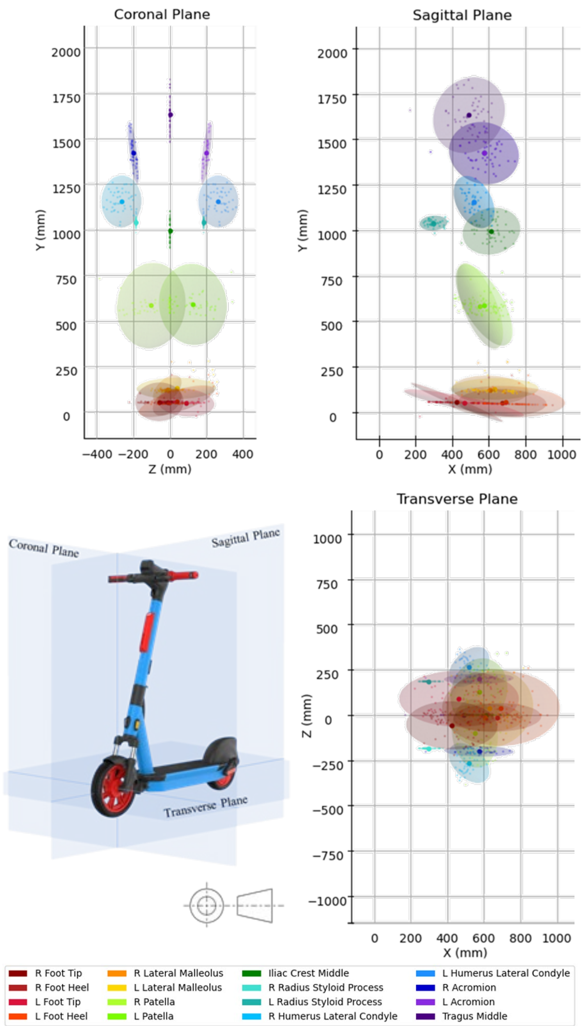

Figure 5: 3D Absolute Global Landmark Positioning (95% Confidence Ellipsoids)

Confidence intervals for absolute 3D rider positioning indicate low variability in relative height positioning of upper body parts in the three axes. The highest relative to height variability is found in the foot in the transverse plane coordinates and in the Z coordinate of the knee. The foot variability is explained by the observed different foot configurations, and the knee Z variability could be explained by BMI, requiring further investigation.

The main limitation of this study was the use of an anthropometric distribution to built the 3D landmark positioning from 2D coordinates, as this assumption was not fully supported by the sample quality analysis. Suggested future research includes investigating the influence of different positions, including those using the dominant or non-dominant leg as a foot support, on the likelihood and severity of injury in an incident.

CONCLUSION

This study aimed to describe the average rider position on e-scooters in 84 volunteers using 16 anthropometric landmark points. The results obtained are intended to refine experimental and simulation testing methods and ultimately provide a basic understanding of injury mechanisms in e-scooter incidents.

TRAFFIC SAFETY IMPLICATIONS

This study provides a new and novel understanding of the average positioning of e-scooter riders and its possible effect as a boundary condition on the outcome of injurious or fatal events from a biomechanical standpoint. The implications for traffic safety are significant; understanding the interaction between rider characteristics and injury mechanisms could lead to more effective prevention or mitigation strategies, such as new legislation or specific safety systems, potentially reducing the incidence and severity of e-scooter-related injuries.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to RideDott (Safe Mobility project) and Comillas Pontifical University (IASPE project) for their partial funding of this research.

REFERENCES

Consumer Product Safety Commission (CPSC). Micromobility Products: Related Deaths, Injuries, and Hazard Patterns 2017-2022. 2022.

National Association of City Transportation Officials (NACTO). Shared Micromobility in 2022. 2022.

National Association of City Transportation Officials (NACTO). Shared Micromobility in the U.S. 2020-2021. 2021.

National Health and Nutrition Examination Survey (NHANES). Anthropometric Reference Data for Children and Adults: United States, 2011–2014. 2016.

National Highway Traffic Safety Administration (NHTSA). Traffic Safety Facts: 2021 Data. 2023.

National Transportation Safety Board (NTSB). Micromobility: Data Challenges Associated with Assessing the Prevalence and Risk of Electric Scooter and Electric Bicycle Fatalities and Injuries. 2022.

World Health Organization. Global Status Report on Road Safety 2023. 2023.

AAAM Student Symposium
November 11, 2024. Seoul, South Korea

Preliminary Results from Tech Savviness as a Mediator of Older Adults' Likelihood of Adoption of Automated Vehicles

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INTRODUCTION

Automated vehicles, or vehicles that navigate and perceive through the use of artificial intelligence (AI), are posed to change the landscape of American transportation and have the potential to bring additional ease and safety to transportation. While the majority of research on automated vehicles has been focused on the technological advancements and safety measures regarding the vehicle's AI, it is crucial to explore how prospective users, particularly older adults (aged 65 or older) who may have more to gain from automated transportation, perceive this emerging technology. As older adults' potential benefits are contingent upon their willingness to embrace this new technology and adapt to its use, knowledge about potential mediators that may ingratiate this technology to older adults will be key information for policymakers, designers, and stakeholders. As such, this research seeks to investigate how attitudes towards automated vehicles vary with age, with special focus on how older adults differ from their younger counterparts. This research will test if tech savviness, here measured by the proxy variable of frequency of internet use, is a mediator of older adults' likelihood of adoption of automated vehicles.

The existing literature reveals a multitude of studies on age, tech savviness, and automated vehicles along with several papers focused on analyses of previous surveys of the American Trends Panel. Despite this, there is a noticeable gap in research exploring older adults' relationship with automated vehicles. Studies that focus on older adults tend to be of smaller qualitative samples or only include older adults with no younger group to act as a comparison (Abdelrahman et al., 2020, Kadylak et al., 2021). Many studies not specifically focused on older adults will note significant age differences, then will explore implications for young adults only (Mesch and Dodel, 2022, Nair and Bhat, 2021).

Studies on older adults commonly examine how demographic characteristics, such as age, and less directly mutable characteristics, such as attitudes, relate to likelihood of adoption for automated vehicles (Rahman et al., 2020, Kadylak et al., 2021). In some aspects, women, including older women, have a higher likelihood of adoption of automated vehicles in this dataset. This differs from results from previous studies which show that men had higher levels of likelihood of adoption (Mesch and Dodel, 2022, Nair and Bhat, 2021).

METHODS

This study is a secondary analysis of the American Trends Panel conducted from November 1st through November 7th, 2021 (Pew Research Center, 2023). The American Trends Panel is a nationally representative panel of adults in the United States fielded by the Pew Research Center designed to gather data on various social, political, and economic issues over time. The Pew Research Center recruits panelists through a combination of random sampling and recruitment methods. Initially, a random sample of U.S. adults is selected to participate in a survey. This sample is invited to join the panel, and those who agree to participate become panel members. To ensure that the panel is representative of the U.S. population, Pew researchers apply statistical weights to the survey data. These weights account for factors such as demographics, internet access, and non-response, among others.

The Pew Research 2021 survey of the American Trends Panel initialized the automated vehicle question block with the item "How much have you heard or read about driverless passenger vehicles?" with options "A lot, A little, Nothing at all". Respondents who answered "Nothing at all" were not surveyed on any further items in the automated vehicle question block. For respondents who had some measure of prior knowledge about automated vehicles as measured in the initial item, additional items were asked that measured personal attitudes, use cases, and predictions in regard to automated vehicles. Personal attitude items included measures of "personally want[ing] to ride" and "how comfortable" the respondent would feel "sharing the road with them" as well as their attitudes regarding the societal good of automated vehicles. Use case items included respondents' attitudes toward automated vehicles performing a variety of delivery and public transport uses. Prediction items asked about how respondents believed automated vehicles would effect "the number of people killed or injured in traffic accidents" as well as predictions about the independence of "older adults and people with disabilities”, driving stress, and safety.

Preliminary analysis of these survey items was conducted using the r statistical package via linear regression. Items were weighted with the weights provided by the dataset. A path model testing mediation of likelihood of adoption by tech savviness will be included in the final results.

RESULTS

The full sample of 10,260 respondents was divided into two groups based off of respondents’ prior knowledge of automated vehicles. Automated vehicle items were only asked to the 5,153 respondents who had some measure of prior knowledge. Of this analytical sample, 21% were above 65 years of age. Older adults were significantly less likely to agree that automated vehicles would increase the independence of adults 65 and older.

A negative association was seen between age and likelihood of adoption for automated vehicles, suggesting that as age increases, likelihood of adoption of automated vehicles decreases. Additionally, negative association between age and tech savviness was noted, suggesting that as age increases, tech savviness decreases. There was a positive association between tech savviness and likelihood of adoption of automated vehicles, suggesting that as tech savviness increases, likelihood of adoption increases.

DISCUSSION

Older adults were more likely to say they had prior knowledge of automated vehicles. Looking into the 2017 American Trends Panel data yields more knowledge on this. The 2017 iteration of the survey asked an additional question not asked in the more recent data, "Has what you’ve seen or heard about driverless vehicles been mostly positive, mostly negative, or a mix of both?" (Pew Research Center, 2023). On this item older adults were more likely to say that their prior knowledge was negative. Taken together, older adults subjectively rate themselves as having more prior knowledge but qualify that their prior knowledge sources have been mostly negative. This suggests that simple awareness of automated vehicles does not increase likelihood of adoption.

Additionally, preliminary findings of this paper suggest older adults put greater emphasis on the privacy and security of automated vehicles with this finding stronger for women than men. This aligns with previous research showing privacy and security as a major concern among older adults in regard to technology as a whole (Frik et. al., 2019). Targeted advertising and promotional campaigns aimed at older adults should focus on highlighting the specific advantages and safety features of automated vehicles that resonate with this demographic (Abdelrahman et al., 2020). Automakers should prioritize inclusivity in their designs by ensuring that automated vehicles can accommodate the mobility and accessibility requirements of older users. This may include making vehicles wheelchair-accessible or providing additional support for individuals with limited mobility.

Establishing underlying causation is a limitation of this study due to survey items being indirect measures as well as potential interplay between age effects, period effects, and cohort effects. Although causation cannot be directly identified, probable cause for specific effects can be estimated.

CONCLUSION

As the digital landscape continues to evolve, it is becoming increasingly essential for individuals of all age groups to adapt and engage with technology. As older adults become more savvy in their use of smartphones, tablets, and other digital devices for various aspects of their daily lives, they may also become more open to exploring and accepting automated vehicle technology. The preliminary findings of this paper suggests that tech savviness can foster a sense of comfort and trust in the capabilities of automated vehicles, making the transition to this mode of transportation a more natural and appealing choice for older individuals.

NOVELTY/TRAFFIC SAFEY IMPLICATIONS

The older adult population is growing such that the proportion of U.S. adults 65 years and older has increased threefold over the last century and is predicted to number 83.7 million by 2050 (Anderson et al., 2012, Ortman et al., 2014). This growing population will exhibit significant transportation needs while simultaneously facing age-related mobility challenges. These challenges include diminished physical capabilities, reduced reflexes, and potential health conditions that can impact their ability to operate traditional vehicles safely. Drivers aged 75 and older with adverse medical and physical conditions have been linked to an increased risk of crash fatalities while states with frequent in-person license renewal as well as vision and road tests have been linked to lower rates of older adult driving fatalities (Zhang et al. 2000, Grabowski et al., 2004). The intersection of an aging population with growing transportation needs and mobility limitations underscores the pressing importance of accessible and innovative transportation solutions, such as automated vehicles, to cater to the unique requirements of older adults.

By investing in digital literacy and educational initiatives, governments and organizations can empower older adults to embrace technology and automated transportation, thereby enhancing their overall quality of life, mobility, and independence in an increasingly digitized world. These initiatives can include technology training sessions, workshops, and resources that help older individuals become more proficient in using digital devices and applications (Hargittai et. al., 2019). Educational initiatives can also stress the importance of human factors in design, ensuring that the technology is intuitive and user-friendly for older individuals. These campaigns should be specifically targeted at older adults, aiming to alleviate concerns and encourage technology adoption. Addressing the unique concerns and interests of older individuals, such as increased mobility, accessibility, and convenience, can make automated vehicles more appealing.

ACKNOWLEDGEMENTS

Acknowledgments

The author would like to acknowledge the financial support as well as the invaluable mentorship and guidance during the course of this research provided by Dr. Celeste Campos-Castillo at Michigan State University.

REFERENCES

Abdelrahman, N., Haque, R., Polverento, M. E., Wendling, A., Goetz, C., & Arnetz, B. B. (2020). Brain Health: Attitudes towards Technology Adoption in Older Adults. Healthcare, 9(1), 23. https://doi.org/10.3390/healthcare9010023

Blažič, B. J., & Blažič, A. J. (2019). Overcoming the digital divide with a modern approach to learning digital skills for the elderly adults. Education and Information Technologies, 25(1), 259–279. https://doi.org/10.1007/s10639-019-09961-9

Frik, A. (2019). Privacy and security threat models and mitigation strategies of older adults. USENIX. https://www.usenix.org/conference/soups2019/presentation/frik

Grabowski, D. C. (2004). Elderly licensure laws and motor vehicle fatalities. JAMA, 291(23), 2840. https://doi.org/10.1001/jama.291.23.2840

Hargittai, E., Piper, A. M., & Morris, M. R. (2018). From internet access to internet skills: digital inequality among older adults. Universal Access in the Information Society, 18(4), 881–890. https://doi.org/10.1007/s10209-018-0617-5

Kadylak, T., & Cotten, S. R. (2020). United States older adults' willingness to use emerging technologies. Information, Communication & Society, 23(5), 736–750.

Mesch, G. S., & Dodel, M. (2022). The acceptance of driverless cars: the roles of perceived outcomes and technology usefulness. American Behavioral Scientist, 67(14), 1736–1754. https://doi.org/10.1177/00027642221127250

Nair, G. S., & Bhat, C. R. (2021). Sharing the road with automated vehicles: Perceived safety and regulatory preferences. Transportation Research Part C: Emerging Technologies, 122, 102885. https://doi.org/10.1016/j.trc.2020.102885

Pew Research Center. (2023, September 22). American Trends Panel Datasets | Pew Research Center. https://www.pewresearch.org/american-trends-panel-datasets/

Portz, J. D., Bayliss, E. A., Bull, S., Boxer, R. S., Bekelman, D. B., Gleason, K., & Czaja, S. J. (2019). Using the Technology Acceptance Model to explore user experience, intent to use, and use behavior of a patient portal among older adults with multiple chronic conditions: Descriptive Qualitative study. Journal of Medical Internet Research, 21(4), e11604. https://doi.org/10.2196/11604

Tsertsidis, A., Kolkowska, E., & Hedström, K. (2019). Factors influencing seniors' acceptance of technology for ageing in place in the post-implementation stage: A literature review. International Journal of Medical Informatics, 129, 324–333. https://doi.org/10.1016/j.ijmedinf.2019.06.027

Zhang, J., Lindsay, J., Clarke, K., Robbins, G., & Mao, Y. (2000). Factors affecting the severity of motor vehicle traffic crashes involving elderly drivers in Ontario. Accident Analysis & Prevention, 32(1), 117–125. https://doi.org/10.1016/s0001-4575(99)00039-1

Using Machine Learning to Identify Crash Factors Associated with Severe Distal Tibia Fractures

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INTRODUCTION

Distal tibia fractures are notorious for having a poor prognosis due to high rates of clinical complications and long-term functional disability (Joveniaux 2009). The functionality of the ankle is especially important regarding patient quality of life due to its weight-bearing role and its fragility (Rudd 2005). Healing outcomes are closely linked to the fracture type and mechanism of injury; for example, patients suffering fractures involving the articular surface (pilon fractures) report worse ankle functionality and quality of life relative to extraarticular fractures (Van den Berg 2016) (**Figure 1D**). Low-energy traumatic events, associated with rotational injury mechanisms, often result in extraarticular or non-comminuted, partial articular fractures, while high-energy, compressive traumas like motor vehicle collisions (MVCs) and large falls result in complex fractures with worse functional outcomes (Mair 2021).

Distal tibia fractures are often characterized according to fracture patterns that are consistent with certain causal factors and outcomes in both clinical fracture management and crash injury research. For example, the gold-standard clinical fracture classification scale by the Orthopedic Trauma Association (AO/OTA) first differentiates distal tibia fractures into extraarticular, partial articular, and complete articular surface fractures (Meinberg 2018). The Abbreviated Injury Scale (AIS) distal tibia fracture codes account for these same characteristics, highlighting their importance in the clinical setting (**Figure 1A-C**). Fracture type can vary based on relevant crash factors such as foot position during the event; a plantarflexed foot is more likely to result in posterior tibia fractures, while dorsiflexion results in anterior fractures (Krettek 2015) (**Figure 1E**). The most severe fractures are associated with primarily axial loading, while the most frequent, those to the medial malleolus of the distal tibia, occur due to a number of mechanisms: eversion, inversion, torsion, etc. (Salzar 2015). Beyond loading direction, a variety of crash factors such as sex, age, BMI, and delta-v are known to affect lower extremity injuries (Forman 2019). For distal tibia fractures, age, belt use, and delta-v were significantly correlated with injury risk (Bangert 2023). There is a clear relationship between specific features of the crash event and distal tibia injury outcomes.

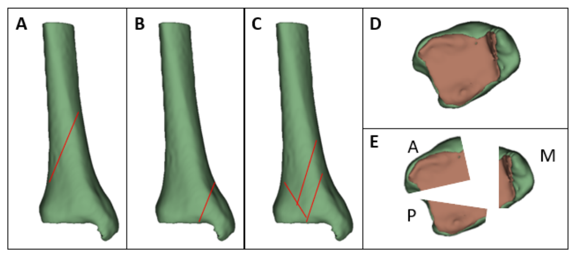

Figure 1. 3D renderings of AO/OTA distal tibia fracture classifications (3DSlicer): (A) extraarticular (AO/OTA - A) (AIS: 854351.2 and 854352.3), (B) partial articular (AO/OTA - B) (AIS: 854361.2 and 854362.3), (C) complete articular (AO/OTA - C) (AIS: 854371.2 and 854372.3). (D) Inferior view of the distal tibia articulating surface, and (E) anterior, posterior, and medial fragments representative of those often present in pilon fractures.

Correctly classifying the degree of distal tibia articular surface involvement is important for determining patient outcomes, yet poor interobserver agreement has been frequently identified. Agreement on the level of articular surface fracture involvement using 2D x-ray imaging is often poor (Martin 1997). While the use of computed tomography (CT) improves reliability, the level of agreement is still inadequate for clinical research (McHugh 2012). Machine learning (ML) classifiers are an emerging technique that can predict outcomes based on underlying data structures. Furthermore, they can identify significant factors related to crash injury severity (Chen 2016). Currently, no models have used ML to classify or identify factors relevant to clinical distal tibia fracture types. Identifying crash factors relevant to fracture type and novel classification tools are needed to inform research on factors that influence clinical fracture outcomes. The goal of this study was to train a random forest ML algorithm on graded distal tibia fractures from real-world crashes to identify crash, vehicle, and occupant factors related to certain fracture grades.

METHODS

Data Source

This study used in-depth crash data from the Crash Investigation Research and Engineering Network (CIREN) which samples crashes in the US where occupants were transported to a level I trauma center. CIREN includes highly detailed patient medical data, including x-ray and computed tomography (CT) radiology of each injury.

Case Selection

Only frontal collisions were considered to control the tibial loading pattern, and rollover or ejection cases were excluded (**Table 1**). Only male or non-pregnant female occupants over the age of 14 years were considered for this analysis. Due to differences in passive safety systems between the front and rear seating rows, only drivers and right front passengers (RFP) were included. Finally, only cases with available CT radiology and without missing data entries for the model features were included.

Table 1. CIREN case count at each level of inclusion.

Case Selection Criteria	Case Count
Cases from 8/31/2017-2/6/2024	1,262
AIS code distal tibia fracture	124
Case with CT radiology	76
Male and non-pregnant female	74
Frontal area impact crash	70
Non-rollover/ejection	67
No missing values in model features	**33**

Clinical Fracture Classification

To generate ground truth classification data for our Random Forest Classifier, all 33 CIREN cases were visualized in 3DSlicer and graded using OA/OTA guidelines by two researchers trained by a clinician at Carillion Clinic. To determine the degree of articular surface fracture involvement, graders were advised to view the sagittal and coronal planes and note if any fracture lines are present in the tibial plafond. Type A fractures are extraarticular, meaning no fracture line was noted through the plafond of the tibia. Type B fractures are partial articular, meaning the plafond was partially separated from the tibial shaft in the crash. Finally, type C fractures are cases where the plafond is completely separated from the tibial shaft (Figure 1). Disagreements between graders were settled by selecting the highest severity grade, i.e., C is more severe than B, and B is more severe than A. The inter-grader agreement was computed using the weighted Cohen's Kappa coefficient of agreement since the grades are leveled. The consensus grades of the two graders were also compared to the AIS rated articular surface involvement, consistent with AO/OTA grades.

Random Forest Classifier

A random forest classifier is a supervised ML algorithm that groups cases into pre-identified bins according to similarities among the model features. The model uses feature importance values - a quantification of how well a feature splits the data into categories - to drive classification. In this study, a random forest was constructed using the consensus grades as ground truth. A 10-fold cross validation was used to test the accuracy of the model, shuffling 80% randomly for training a random forest with 10 decision trees. The crash factors included in the model were age, BMI, sex, mechanism of injury, knee bolster airbag deployment, contributing factors causing the injury, footwear, seat location, seat track position, and vehicle curb weight.

RESULTS

The most common fracture type for each grader was complete articular surface fractures (Type C, **Figure 2**). Weighted Cohen's Kappa coefficients revealed moderate agreement (0.60) between the OA/OTA grades in this study compared with AIS and substantial agreement (0.84) between the OA/OTA graders. The top 5 important features for ML classification were crash speed, vehicle mass, and age (**Table 2**). The contingency table (**Table 3**) presents the grades from this study compared with the random forest classifier: the overall accuracy of the model was 47.8%.

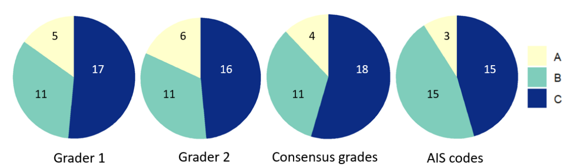

Figure 2. Classifications of degree of articular surface involvement for the CIREN distal tibia fractures graded by each source.

Table 2. Top 5 feature importance in model.

Feature Name	Importance
Delta-v	0.152426
Curb weight	0.12252
Age	0.105806
BMI	0.101454
Compression	0.043208

Table 3. Random forest predicted grades vs. consensus grades.

Random Forest Classification	Consensus Fracture Grades: A	B	C
A	2	1	0
B	0	3	6
C	2	7	12
Acc.	**50%**	**27.3%**	**66%**

DISCUSSION

The results of this study indicate that trained graders have adequate agreement when classifying the degree of articular surface fracture involvement using AO/OTA guidelines. The lower consensus grade agreement with AIS suggests the type of training influences accuracy. Previous studies suggest that Cohen's Kappa of 0.6 is the threshold for studies to be considered adequately robust for clinical research (McHugh 2012). This study stated that a coefficient of agreement of 0.6 corresponds to 35% of the data being reliable, which could lead to inconsistencies for studies using 2D radiology to classify fractures. Future studies could examine grader agreement using 3D segmented models, which help users identify fracture details often missed with 2D imaging. Limitations of the study design include possible bias in our manual grading introduced by our training process as well as overestimation of more severe fracture types in our consensus grades. Future studies should consider a joint case review to classify cases with inconsistent classifications and compare random forest classifier outcomes to determine sensitivity to ground truth labeling.

The random forest classifier in this study produced an accuracy of 47.8% using the consensus grades and 44% using AIS grades, which is better than random chance (33% for 3 categories). This suggests that the crash features were indeed related to the tibia fracture grade. Age, BMI, and delta-v were identified as critical features in determining fracture outcomes, similar to previous studies on lower extremity injury risk factors (Forman 2019). The mechanism of compression was related to the fracture type according to this model, which agrees with (Salzar 2015): compression often results in complete articular fractures while other fractures occur due to a variety of mechanisms. **Table 4** shows that C fractures were the easiest for the model to predict, while B fractures were more often classified incorrectly. This could be a consequence of a small sample, which cannot capture the mechanistic variability due to the variety of mechanisms resulting in B fractures. Future studies could binarize the fracture types into complex (type C and comminuted type B) and simple (type A and non-comminuted type B). These binary categories have been related to functional outcomes previously (Van den Berg 2016), and this would likely result in more balanced categories as well as reduce the sample size needed to have high accuracy.

CONCLUSION

Overall agreement between the graders in this study and AIS was good, according to the weighted agreement coefficient. This suggests that current methods to assess distal tibia articular surface fracture involvement are reproducible, yet studies have claimed scores that are considered good still correspond with unreliable data. Future studies should consider other clinically relevant classifications to examine how other clinical fracture types relate to crash, vehicle, and occupant factors as well as functional outcome measures. The results of the random forest classifier indicated that crash speed, vehicle mass, age, BMI, and the mechanism of compression are associated with the degree of distal tibia articular surface fracture.

NOVELTY/TRAFFIC SAFEY IMPLICATIONS

AIS has proven to be a robust system for classifying the severity of injuries due to a plethora of research informing designers of relevant factors regarding clinical severity. Despite its usefulness, clinical fracture classifications using 2D radiology have shown agreement indicating potentially unreliable data, similar to the agreement between AIS and graders in this study. Further analysis is necessary to determine if this agreement is sufficient and if 3D models can improve the accuracy of the classifications to better stratify occupant injuries, in line with expected long-term healing outcomes. The random forest classifier showed better accuracy than random chance, indicating fracture type can be predicted given relevant crash factors. This suggests certain age, BMI, delta-v, vehicle mass, and tibia loading mechanisms are closely related to fracture outcomes in MVCs.

ACKNOWLEDGEMENTS

The authors recognize Dr. Rodney Rudd and Dr. Luke E. Riexinger for their support in identifying critical factors related to ankle fractures, CIREN data table navigation and structuring of the ML methodology.

REFERENCES

Association for the Advancement of Automotive Medicine, The Abbreviated Injury Scale 2015, 2015
C. Chen, et al., "Investigating driver injury severity patterns in rollover crashes using support vector machine models," Accident Analysis & Prevention, 2016
C. Krettek et al., "Pilon fractures. Diagnostics, treatment strategies and approaches, 2015
L. G. Bangert, et al., "Do Females Have a Higher Risk of Suffering Distal Tibia Fractures in Frontal Car Crashes?," in International Research Council on Biomechanics of Injury, 2023
J. Forman et al., "Automobile injury trends in the contemporary fleet: Belted occupants in frontal collisions," Traffic Injury Prevention, 2019
J. S. Martin, et al., Assessment of the AO/ASIF Fracture Classification for the Distal Tibia," J Orthop Trauma, 1997
J. Van den Berg, et al., Functional outcome and general health status after treatment of AO type 43 fractures," Injury, 2016
M. L. McHugh, "Interrater reliability: the kappa statistic," Biochem Med, 2012
E. Meinberg,, "Fracture Classification Compendium-2018.," J Orthop Trauma, 2018
O. Mair et al., "Management of Pilon Fractures—Current Concepts," Front Surg, 2021
P. Joveniaux et al., "Distal tibia fractures: management and complications of 101 cases," International Orthopaedics, 2010
P. J. Schluter, et al., "Validating the Functional Capacity Index: A Comparison of Predicted versus Observed Total Body Scores," J of Trauma and Acute Care Surgery, 2005
R. S. Salzar et al., "Leg, Foot, and Ankle Injury Biomechanics," Accidental Injury Biomechanics and Prevention, 2015.
R. W. Rudd, "Injury tolerance of the human ankle in impact-induced dorsiflexion," University of Virginia, 2005

AAAM Student Symposium
November 11, 2024. Seoul, South Korea

Response of Relaxed Occupants in Frontal Crash

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INTRODUCTION

In order to comprehensively analyze the biomechanical response of occupants in a frontal collision, it is necessary to conduct experiments using Post-Mortem Human Surrogates (PMHS) in various seated positions. Richardson et al. conducted sled tests simulating a frontal collision at 50 km/h (deceleration of 30g) to evaluate the kinematics and injury responses of seated PMHS. They used five standard (50th percentile) adult male PMHS and applied a simplified semi-rigid seat with submarine prevention feature, along with a three-point safety belt incorporating pre-tensioners and load limiters. During the frontal collision sled tests, they measured the overall movement and localized accelerations of the head, pelvis, and spine, as well as the reaction forces on the seat and safety belt. The results of the experiments showed that due to the high restraint forces from the seat and safety belt and the relatively unfavorable occupant kinematics, injuries to the pelvis, spine, and chest occurred in seated positions. Richardson et al. reported that the analysis of occupant kinematics and injury outcomes provides a basis for developing new injury criteria for the lumbar spine and pelvis, and for evaluating Anthropomorphic Test Devices (ATD) and Human Body Models (HBM) of seated occupants. While various studies are underway to analyze occupant kinematics and injury outcomes based on passenger posture in autonomous vehicles during crashes, most of them are at a fundamental research stage. Therefore, in this study, an analysis of occupant kinematics and injuries of autonomous vehicle passengers based on the conditions of the passenger safety systems (safety belt and airbag) was conducted. A finite element model of the occupant (Hybrid-III dummy) - vehicle - restraint system was developed, and frontal crash simulations were performed to analyze the expected occupant kinematics and injuries in autonomous vehicles.

METHODS

In this study, we constructed an occupant kinematics analysis model by applying finite element models of both typical seated posture and reclined posture occupants to the frontal collision sled analysis model (seat and safety belt), using the nonlinear finite element program LS-DYNA (ANSYS, Inc) for dynamic analysis. The frontal collision pulse applied in the analysis model was obtained from measurements in the NHTSA New Car Assessment Program (Frontal Barrier Impact Test) with an analysis time set to 120 msec. The seat model utilized a semi-rigid seat designed by Uriot et al., incorporating features such as seat pan and submarine prevention structure, and employed a finite element model of the semi-rigid seat developed by Gepner et al. The safety belt used was a Visual seat-belt with pre-tensioner and load limiter functions and the characteristic values of each function were adopted from Han et al. The positions of safety belt components such as D-ring and Buckle were set according to the layout conditions of a typical midsize passenger vehicle. The occupant model used the Hybrid-III 50th percentile male dummy model, with the reclined posture modeled by tilting the upright posture model by 20°, as described by Han et al. The occupant kinematics analysis model for frontal collision is depicted with a total of 88,746 elements computed up to 120 msec. The differences in occupant behavior based on two seating postures (upright and reclined) are illustrated, showing the calculated disparities in occupant behavior according to seating posture. Fig. 1 presents the trajectories of major occupant body parts along with PMHS experimental results over time. In Fig. 1, although there are some differences observed in the head trajectory of the reclined model compared to PMHS experimental results, the movements of the chest and pelvis generally exhibit similar trends to the PMHS results. The maximum acceleration value of the head is calculated to be approximately 42% higher in the reclined model compared to the upright model, and the maximum values of the reclined model are similar to those of PMHS Upper. The changes in chest acceleration over time for both seating postures, closely resemble the chest acceleration results of PMHS. In the comparison of pelvis acceleration, the maximum value of the upright model is slightly larger than that of the reclined model and the maximum value of PMHS Upper results. The changes in head angular velocity in the Y-axis, the reclined model results increase compared to the upright model, exhibiting a trend similar to PMHS results. In the comparison of seat reaction force variations, the results of the reclined model show approximately 6% higher maximum values compared to the upright model, showing a very similar trend to PMHS Lower.

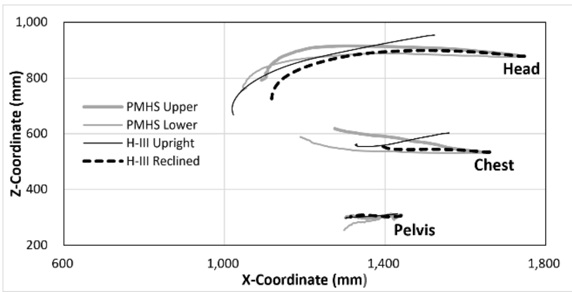

Fig. 1 Occupant trajectories of relaxed occupants

Based on the analysis results of occupant kinematics, as well as injuries to major body parts of occupants in typical seated posture and reclined posture, we evaluated the influence of an airbag model on reducing occupant injuries by applying a finite element model of reclined posture occupants to the frontal collision sled analysis model (seat, safety belt, and airbag). In this study, we performed occupant kinematics analysis by changing the position of the airbag and analyzing occupant behavior and injuries based on the contact between the airbag and occupants. With the anticipated transition of occupants from drivers to general passengers in autonomous vehicles, where occupants no longer need to control the steering mechanism and the interior space may change, we applied a front passenger airbag model (Inflator type: dual state, Volume: 86 liters) typically found in midsize passenger cars. We conducted occupant kinematics analysis while varying the position of the airbag. Apart from the airbag model, the conditions of the analysis model were consistent with those described earlier, and the positions of safety belt components such as D-ring and Buckle were set identical to the layout in previous studies. Figure 2 illustrates the time-dependent behavior of occupants and the airbag for the base model with the applied airbag and the model with the airbag shifted +150mm along the X-axis. After approximately 80 msec, differences in occupant behavior due to the deployment of the airbag and contact with the dummy model became evident.

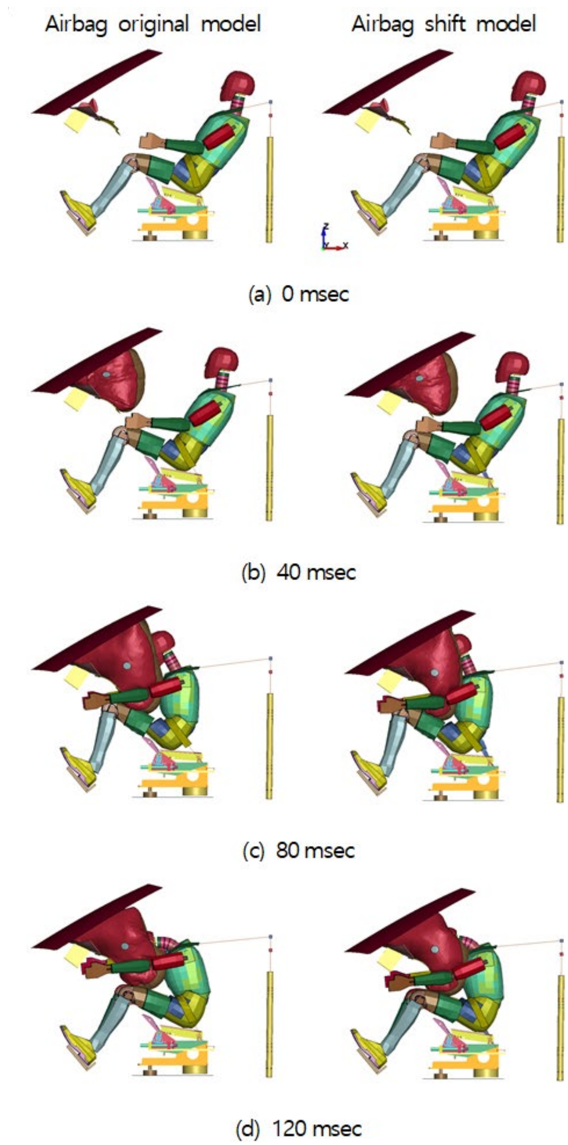

Fig. 2 Occupant and airbag model behaviors

RESULTS

In the frontal collision analysis results applying a model where the airbag was shifted +150mm along the X-axis, it was analyzed that the maximum head acceleration decreased compared to the model with the base airbag. However, when applying a model where the airbag was moved ±50mm along the Z-axis, similar values to the original model were computed, suggesting the need for comprehensive analysis regarding the distance and deployment direction between reclined posture occupants and airbags through further research.

DISCUSSION

The outcomes of this study could serve as foundational data for designing new restraint systems for reclined posture occupants in autonomous vehicles. Furthermore, based on these results, it is anticipated that comparative and validation studies on the behavior and injuries of reclined posture occupants in autonomous vehicles, utilizing various crash dummy models and human body models, will be conducted.

CONCLUSION

In this study, we constructed finite element models of automobile safety restraint systems (such as seat belts and airbags) and dummy models to analyze the behavior and injuries of occupants in frontal collisions based on their seated posture. Additionally, we analyzed the effects of the presence and positioning of airbags on occupant behavior and injuries. It was calculated that occupants experience increased injuries when adopting a reclined posture compared to the typical upright driving posture. Moreover, significant variations in occupant behavior and head injuries were observed based on the presence and positioning of airbags.

NOVELTY/TRAFFIC SAFEY IMPLICATIONS

Overall comprehensive research and development of automobile safety restraint systems suitable for reclined posture occupants are warranted.

ACKNOWLEDGEMENTS

This work is supported by the Korea Agency for Infrastructure Technology Advancement (KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant RS-2021-KA160637).

REFERENCES

National Highway Traffic Safety Administration, 2018, “Automated Driving Systems 3.0: Preparing for the Future of Transportation”, U.S. Department of Transportation.

Forman, J., Lin, H., Gepner, B., & Wu, T, 2019, “Occupant safety in automated vehicles-effect of seatback recline on occupant restraint”, International journal of automotive engineering, Vol. 10 No. 2, pp. 139-143.

R. Richardson, J. Donlon, M. Jayathirtha, J. Forman, G. Shaw, B. Gepner and J. Kerrigan, 2020, “Kinematic and Injury Response of Reclined PMHS in Frontal Impacts”, Stapp Car Crash Journal, Vol. 64, pp. 83-153.

R. Schnorenberg, 2018, “Final Report of New Car Assessment Program Frontal Impact Testing of a 2018 Honda Accord 1.5T LX 4-Door Sedan, NHTSA No.: M20185300”, National Highway Traffic Safety Administration Report No. NCAP-MGA2018-024.

Uriot, J., Potier, P., Baudrit, P., Trosseille, X., Petit, P., Richard, O., Douard, R., 2015, “Reference PMHS sled tests to assess submarining”, SAE Technical Paper, No. 2015-22-0008.

Gepner, B., Rawska, K., 2019, “Challenges for Occupant Safety In Highly Automated Vehicles Across Various Anthropometries”, 26th International Technical Conference on the Enhanced Safety of Vehicles ESV, Eindhoven, Netherlands, 10th June-13th June, Paper No. 19-0335.

Singh, H., Ganesan, V., Davies, J., Paramasuwom, M., and Gradischnig, 2018, “Vehicle interior and restraints modeling development of full vehicle finite element model including vehicle interior and occupant restraint systems for occupant safety analysis using THOR dummies”, National Highway Traffic Safety Administration, Report No. DOT HS 812 545.

AAAM Student Symposium
November 11, 2024. Seoul, South Korea

Investigation of Traffic Accidents for the Establishment of Pedestrian Injury Database

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INTRODUCTION

2022 In 2022, a total of 196,836 crashes occurred in Korea, of which 2,735 died. Of the 2,735 fatalities, 933 (34.1%) were confirmed as pedestrians, and one in three crashes fatalities was found to be a pedestrian. This is approximately 1.7 times higher than the OECD member country average of 19.3%. Currently, the actual automobile accident investigation system is being constructed and operated through the Korean In-Depth Accident Study (KIDAS). However, as the only research institute in Korea, it has limitations in being limited to certain regions and only collects and analyzes information focused on occupants and vehicles, such as single-vehicle crashes or car-to-car crashes, showing a vulnerability in collecting and analyzing information on pedestrians. In order to analyze the factors that may have an impact when a pedestrian crashes occurs from multiple angles, we will classify the information into patient information, vehicle information, and environmental information and conduct a thorough investigation. Afterwards, we plan to compile the surveyed data and build a database for analysis of human injury mechanisms. Based on the finally constructed database, we aim to contribute to reducing and preventing the severity of pedestrian crashes through Haddon's matrix analysis.

METHODS

Among patients who visited a local emergency medical center from October 4, 2023 to April 8, 2024 (day 188), patients who were injured or died due to a crashes were eligible. Data was collected divided into patient, environment, and vehicle information. We checked the emergency medical center electronic medical records and prehospital emergency medical record, and collected the date, time, location, and circumstances of the crashes necessary for the investigation. In addition, the patient's basic information (age, gender, injury site, etc.) was collected, and AIS (abbreviated injury scale) and ISS (injury severity score) were collected through diagnostic images. At the accident site, information about the environment, such as speed limit, slope, pavement condition, presence of sidewalks and lights, was collected, and vehicle information such as vehicle type, skid marks, and speed at the time of collision was collected.

RESULTS

General characteristics of pedestrian traffic accidents

A total of 41 pedestrian cases were collected. It consists of 26 men and 15 women. The mean age was 59.3 years (±22.8), 20 were elderly (≥65) and 21 were non-elderly (<65), and the mean MAIS was confirmed to be 3.2 and ISS to be 20.7. It has been confirmed that 18 accidents occurred during the day (06:00-18:00) and 23 at night (18:01-05:59). The location of the accident was 19 at the crosswalk, 9 on the roadway, 9 other (parking lot, farm road, etc.), and 4 on the shoulder. As for the types of pedestrian accidents, there were 14 Wrap projection cases, 14 forward projections, 2 Fender faults, 1 Roof fault, 0 Somersaults, 9 Dragging cases, and 1 other cases, with Wrap projection and forward projection types jointly the most.

Comparative Analysis of Deaths and Non-Deaths

Of the total 41 subjects, 12 died, with an average age of 71 years (±11.8), and the average age of non-death patients was 54.4 years (±24.6). The average ISS of deceased people is 37.6, and the average ISS of non-dead people is 13.8. The accident occurrence times of the deceased were confirmed to be 4 during the day and 8 at night, and for the non-dead, 14 occurred during the day and 15 at night. The crashes locations for fatalities were confirmed to be 6 crosswalks, 3 roadways, 1 shoulder, and 2 other cases. For non-fatal crashes, 13 were crosswalks, 6 roadways, 3 shoulder roads, and 7 other cases. In the case of pedestrian accident types, the most common deaths occurred in the following order: wrap trajectory (5 cases), dragging (4 cases), forward projection (2 cases), and fender vault (1 case). It was confirmed that the most common non-death cases occurred in the following order: forward projection (12 cases), wrap trajectory (9 cases), dragging (5 cases), and fender vault/roof vault/others (1 case).

DISCUSSION

In Korea, the crashes death rate is decreasing every year, but pedestrians account for one-third of crashes deaths. We wanted to know the general characteristics of pedestrian crashes and compare fatalities with non-fatalities to identify differences. It cannot be said that the amount of crashes data collected to date is sufficient. However, data collection for research will continue until 2027. Men had a higher crashes rate than women, and there was no difference between the elderly and non-elderly. If the ISS is 16 points or higher, the patient is accepted as a severe trauma patient. The average ISS for pedestrians is 20.7, so the severity can be said to be dangerous. The average age of those who died was higher than that of those who did not die, and there were many accidents at night. In addition, the deceased frequently showed the wrap trajectory type, whereas the non-deceased frequently showed the forward projection type. As for the location of accidents, crosswalks show the highest accident rate for both fatalities and non-fatalities. Through these research results, it was confirmed that many deaths occur at crosswalks at night, and prevention measures and additional research on this are needed.

CONCLUSION

It can be said that men have a higher accident rate than women, there is no difference between the elderly and non-elderly, and pedestrian crashes are on average severity is high. Those who died were older than those who did not die, had more crashes at night, and had a more frequent wrap trajectory type. It was confirmed that most crashes occurred at crosswalks for both fatalities and non-fatalities.

NOVELTY/TRAFFIC SAFEY IMPLICATIONS

Since data is collected focusing on pedestrian crashes, which account for one-third of traffic accident deaths, there is social benefit as it is used as basic data that can be used in future research and policy development.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT). (2023R1A2C2008100)

REFERENCES

Bolorunduro OB, Villegas C, Oyetunji TA, et al. Validating the Injury Severity Score (ISS) in Different Populations: ISS Predicts Mortality Better Among Hispanics and Females. J Surg Res 2011;166:40-44.

Greenspan L, McLellan BA, Greig H. Abbreviated Injury Scale and Injury Severity Score: a scoring chart. J Trauma Acute Care Surg 1985;25(1):60-64.

Siwoo Kim, Jaewan Lee, Younghan Youn (2014), "A Study on the Construction of the Database Structure for the Korea In-depth Accident Study", Transactions of Korean Society of Automotive Engineers, 22(2), 29-36.

The Road Traffic Authority, TASS traffic accident analysis system, http://taas.koroad.or.kr (2024.03.22)

Determining change in initial loading condition of the pelvis in relation to motorcycle design

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INTRODUCTION

Traffic related road injuries are the eighth leading cause of death globally and road traffic crashes are estimated to be the third leading cause of death by the year 2030. Motorcyclists alone account for about 28% of all road deaths (World Health Organization, 2018). Compared to car occupants, fatality rates per km travelled are 30 times more for motorcyclists and this problem is bound to increase due to the rapidly growing motorcycle industry (Huggins, 2013).

Even with growing demand, there has been little progress in motorcycle safety. There is still a gap in understanding how riders physically interact with their motorcycles in crashes. Finite element models and anthropometric test devices (physical and virtual) have been developed to evaluate loads on the motorcycle rider in crashes (Carroll et al., 2023; Pipkorn et al., 2023); however, they do not entirely mimic how a rider responds in a crash.

Motorcycle fuel tanks have been identified as a critical point of contact to the pelvis of the rider in a crash. Fuel tanks are the primary source of pelvic injuries to motorcyclists and influence overall rider kinematics (Meredith, L et al., 2016). Pelvic injuries occur in up to 20% of hospitalized riders with pelvic fractures and urogenital injuries the most common pelvic injury types in motorcycle crashes (Terrier et al., 2017).

Different motorcycle designs induce different riding postures which likely position the rider's pelvis differently in relation to the fuel tank. Previous studies have shown that motorcycle design and rider anthropometry influence overall seated posture, however these studies have focused on comfort and ergonomics only (Arunachalam et al., 2019). Pelvis orientation in relation to the fuel tank, gender and rider anthropometry is critical in understanding pelvic-fuel tank interaction yet the influence on motorcycle design remains unknown. Moreover, in a crash when a rider impacts the fuel tank, the pelvis of the rider experiences crash loading in the anterior-posterior (A-P) direction. Previous studies have investigated pelvic injury mechanisms in car occupants and in blast events (Franklyn & Stemper, 2017). However, limited studies have examined pelvic loading conditions relevant to motorcyclists (Masson et al., 2005). Understanding how motorcycle design influences the initial loading orientation of the pelvis and subsequent mechanisms of injury is critical for simulating accurate motorcycle crashes physically and computationally. The inability to do this is inhibiting advancement in innovative developments and evaluation of novel safety technologies for motorcycles.

We are undertaking a holistic approach to understanding initial loading condition of the pelvis and overall rider kinematics in a crash. Figure 1 summarizes our current program of work.

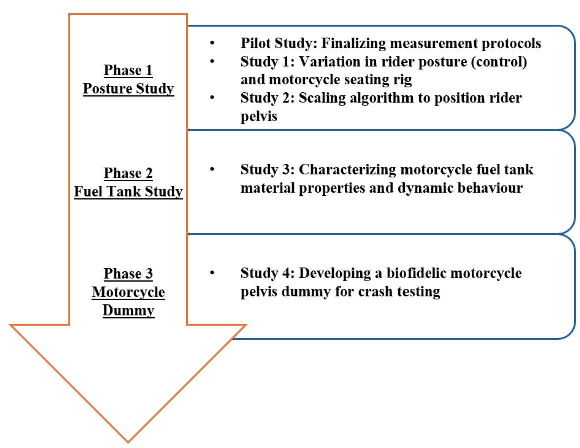

Figure 1: Overview of PhD body of work

Phase 1 will comprise of two studies and will focus on studying changes to pelvic orientation and rider posture with respect to different motorcycle designs. The output of Study 1 will be a motorcycle seating rig that mimics posture of four motorcycle types which will be used in Study 2 to investigate changes in posture at a population level. The output of which will be a scaling algorithm to estimate pelvic position of the rider in relation to rider anthropometry and motorcycle design.

Phase 2 will focus on mechanically testing motorcycle fuel tanks to study their material properties and dynamic behavior at the pelvis-fuel tank interface.

The output from Phase 1 and Phase 2 will be used to develop a biofidelic pelvis dummy in Phase 3 which mimics rider's pelvic response in a crash scenario. This pelvis dummy will help to facilitate impact testing of motorcycle fuel tanks and testing of other safety devices by accurately replicating human-like pelvis responses.

METHODS

To date, work has commenced on the Pilot study and Study 1. This paper presents preliminary data and reviews the progress of this work.

Pilot Study: 33 motorcycle owners were recruited through social media to bring their motorcycles to the lab. Trained researchers placed 3D markers (25mm Styrofoam balls) on their skin at anatomical joint locations (as recommended by VICON). The participants were asked to assume normal riding position on the restrained motorcycle while a researcher 3D scanned them using a handheld scanner (EinScan HX). The scans were processed using MeshMixer and MeshLab to acquire marker locations in 3D space. These coordinates were further processed in MATLAB to generate anatomical joint angles using kinematic calculations (recommended by VICON).

Study 1: Motorcycle owners are being recruited (n=40) through social media for providing their motorcycles. 10 motorcycles of each type – Naked/Standard, Sports, Adventure and Cruisers will be acquired. 1 male (Height:172cm; Weight: 75kg) and 1 female (Height: 165cm; Weight: 51kg) control rider of approximately 50th percentile will be prepped and seated on these motorcycles similarly as explained above. Two additional markers (medial femoral condyle - knee and medial malleolus - ankle) will be placed on the riders to calculate their corresponding joint centers. The controls will be 3D scanned on the motorcycle and the joint angles will be calculated using the same methodology as the pilot study. 3D scans of the motorcycles will also be taken to obtain measurements of their key design features. A seating rig, adjustable to represent the four motorcycle types, will be built as a result.

Study 2: 220 volunteers (110 male and 110 female) will be recruited through social media. Standard anthropometric measurements, including height, weight, and body segment lengths will be collected. Participants will be 3D scanned while seated on the rig (from Study 1) which will be adjusted to represent the four motorcycle types. Algorithms will be developed to estimated joint location and pelvic position for the males and females with respect to motorcycle design and anthropometry using regression.

RESULTS

Pilot Study: Marker placement and joint angle calculation protocol was finalized to be used in Study 1 and Study 2. In addition, sample size for Study 2 was calculated using ISO 15535 and lumbar extension variability observed in this study to achieve a 5% relative accuracy.

Study 1: Preliminary results presented in this paper are based on 12 motorcycles (3 of each type). Sports motorcycles induced ~14°, 11°, and 10° more anterior pelvic tilt when compared to adventure, cruiser, and naked motorcycles. LSD post hoc test results confirmed that there is a significant difference in pelvic tilt between the sports motorcycles when compared to others. Thus, there was a significant association between motorcycle type and pelvic tilt ($F(3,20) = 11.501$, $p=0.00 < 0.05$). LSD post hoc test results found the average hip flexion angle for adventure motorcycles was significantly different to sports ($p = 0.018$) and cruisers ($p = 0.02$). Overall, there was no significant association with motorcycle type and hip flexion. Sports and cruiser motorcycles on average induced maximum hip flexion of ~65° while adventure motorcycles induced the least (~52°). When controlled for height, gender too had a significant association with hip flexion. On average the male control experienced ~15° more hip flexion to the female control across same motorcycle types. Hip abduction had a significant association with motorcycle type ($F(3,20) = 4.511$, $p=0.014 < 0.05$). LSD post hoc test results found the total hip abduction angle for sports motorcycles was significantly different to adventure ($p = 0.003$) and cruisers ($p = 0.01$) where sports motorcycles induced the maximum total hip abduction of ~58°. There was a significant association between motorcycle types and knee flexion ($F(3,20) = 9.599$, $p=0.00 < 0.05$). and ankle flexion ($F(3,20) = 10.288$, $p=0.00 < 0.05$). Sports motorcycles induced maximum knee flexion (~119°)

while cruisers induced the least (~81°). Cruisers were the only motorcycle type to induce plantarflexion of the ankle. Data collection and analysis continues and results from the 40 motorcycles will be used to identify features of motorcycle design influencing pelvic orientation. The full set of results from this study will be presented at the conference.

Study 2: Results from this study will be presented at the conference.

DISCUSSION

This paper presents work in progress aimed at investigating how differences in motorcycle design result in changes to the initial loading condition of the pelvis in a crash.

Preliminary results from Study 1 show that motorcycle design does induce a change in initial loading condition of the pelvis and changes overall riding posture as well. This change can be attributed to certain key design features of the motorcycles which induce this change in posture. Furthermore, only control riders were used in this study. Therefore, it will be interesting to look at how differences in motorcycle design changes in pelvic position and riding posture on a population level.

Study 2 will investigate changes in pelvis' initial loading condition with respect to motorcycle design at a population level using the seating rig which will induce postures of four generic motorcycle types.

CONCLUSION

By investigating variation in riding posture across different motorcycle types we are hoping to understand the initial loading condition of the rider at the pelvis-fuel tank interface and how that influences overall rider kinematics in a crash.

NOVELTY/TRAFFIC SAFEY IMPLICATIONS

Lower body geometry and correct pelvic orientation is critical for accurately simulating motorcycle crashes using either finite element models or crash test dummies. This accurate representation will aid in the development and evaluation of novel motorcycle safety technologies.

REFERENCES

Arunachalam, M., Mondal, C., Singh, G., & Karmakar, S. (2019). Motorcycle riding posture: A review. In *Measurement: Journal of the International Measurement Confederation* (Vol. 134, pp. 390–399). Elsevier B.V. https://doi.org/10.1016/j.measurement.2018.10.019

Carroll, J., Been, B., & Burleigh, M. (2023). A novel Powered Two-Wheeler rider dummy; specifications and initial testing. *27th ESV NHTSA (No. 23-0132)*.

Franklyn, M., & Stemper, B. D. (2017). The thoracolumbar spine and pelvis: Injury criteria for traumatic spinal and pelvic injury and their current applications. In *Military Injury Biomechanics: The Cause and Prevention of Impact Injuries*. Boca Raton: CRC Press/Taylor & Francis Group.

Huggins, R. (2013). Using speeding detections and numbers of fatalities to estimate relative risk of a fatality for motorcyclists and car drivers. *Accident Analysis & Prevention*, *59*, 296–300. https://doi.org/10.1016/j.aap.2013.06.020

Masson, C., Baque, P., & Brunet, C. (2005). Quasi-static compression of the human pelvis: An experimental study. *Computer Methods in Biomechanics and Biomedical Engineering*, *8*(sup1), 191–192. https://doi.org/10.1080/10255840512331388902

Meredith, L., Baldock, M., Fitzharris, M., Duflou, J., Nevo, R., Griffiths, M., & & Brown, J. (2016). Motorcycle fuel tanks and pelvic fractures: A motorcycle fuel tank syndrome. *Traffic Injury Prevention*, *17*. https://doi.org/10.1080/15389588.2015.1136061

Pipkorn, B., Jakobsson, L., Iraeus, J., & Östh, J. (2023). The SAFER HBM – A Human Body Model for Seamless Integrated Occupant Analysis For All Road Users. *27th International Technical Conference on the Enhanced Safety of Vehicles (ESV)*.

Terrier, J.-E., Paparel, P., Gadegbeku, B., Ruffion, A., Jenkins, L. C., & N'Diaye, A. (2017). Genitourinary injuries after traffic accidents. *Journal of Trauma and Acute Care Surgery*, *82*(6), 1087–1093. https://doi.org/10.1097/TA.0000000000001448

World Health Organization. (2018). *Global status report on road safety 2018. Geneva: World Health Organization*.

An Epidemiological Study of Road Traffic Accidents in Hospitalized Youth Patients: Contributing Factors and Prevention

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INTRODUCTION

The World Health Organization defines Road Traffic Accident (RTA) as "a collision involving at least one vehicle in motion on a public or private road that results in at least one person being injured or killed.", (WHO, 2004). The 2018 WHO report depicted a rise in the absolute number of deaths from traffic accidents worldwide; this put them as one of the top ten leading causes of death worldwide (WHO 2018). Low-income nations bear the highest number of traffic accidents in comparison to more financially developed nations (WHO 2020). This injuries lead a big impact on the victims, including their families and societies.

At present, literature on factors leading to and morbidity from traffic accidents is lacking. Most research uses data on mortality and the number of hospitalizations but does not elaborate on the relationship between causal factors and victims' injury severity nor do they explore the resulting disabilities.

Recognizing and understanding the root causes, extent, and consequences of traffic accidents is the first steps toward developing effective and efficient prevention programs and policies in developing nations.

OBJECTIVES

In view of the above, we aimed to evaluate and identify the factors associated with hospitalizations due to traffic accidents at a tertiary care hospital, as well as the relationship of these factors with injury severity at the time of occurrence as well as thirty days after discharge. We further aimed to study the epidemiology, risk factors and outcomes of hospitalized road traffic injured youth patients in order to give recommendations for prevention.

METHODS

We carried out a retrospective, epidemiological, descriptive and observational study of all youth patients (15–24 years old) who were admitted to the tertiary care government hospital in Maharashtra. CPR Hospital tends to about 2000 trauma patients annually. This tertiary government hospital provides a huge array of general and specialist clinical services.

Data Sources

Medical records from the time of admission were reviewed and used for the study. We collected data on demography (age and gender), crash mechanism, place of injury, road user type, position in the vehicle, speed of the vehicle, use of safety equipment, time of the crash, anatomical body part(s) injured, severity, Revised Trauma Score (RTS), Glasgow coma scale (GCS), intensive care unit (ICU) admission, length of hospital stay, and outcome (survival or death).

Injury grades and severity scoring were also retrieved which was assigned using the Injury Severity Score (ISS) (Maurer A, 2004).

Data Analysis: The data were entered into Microsoft Office Excel and analyzed using SPSS version 16. Appropriate tests of significance were used for comparison and a $P<0.05$ was considered significant.

RESULTS

Personal risk factors: age and gender

There were 2113 patients, 1162 males and 951 females. The mean age (SD) was 19 (2.3) years. There was no statistical association between gender and mortality ($P=0.072$).

Factors related to Injuries: Type of road user and vehicle type

The majority of injured patients were drivers or front-seat passengers (69%), followed by motorcyclists (12%), rear seat passengers (10%), and pedestrians (9%). There was no significant difference ($P=0.081$) in age, GCS, RTS and ISS between vehicle occupants and vulnerable road users (pedestrians, bicyclists, motorcyclists, and quadribike users). Mortality among vehicle occupants was 3% compared with 7% in vulnerable road users. Motorcyclists and cyclists were majority males (97.85%). 232 drivers (11%) and 103 motorcyclists (41%) were under the licensing age in the country (18 years old). The underaged motorcyclists were injured off-road and in the parking or housing areas. Fifty nine percent vehicle occupants were injured in regular compact cars, 34% in sport utility vehicles (like SUVs) and the remaining 7% in other vehicles. Male drivers were significantly more injured compared with females (P=0.021, Fisher's Exact test).

Factors related to Crash mechanism

The most common crash mechanism of injury was found to be the rollover of the vehicle (39%), followed by front impact collision (31%). Secondary roll-over of the car was in 55% of rear-end, 31% of side and of 14% of front- impact accidents. Around 9% of individuals were ejected during the collision. Patients in rollover crashes had a longer stay in the hospital compared with front and side angle crashes (P= 0.041).

Factors related to Speed of the car

The mean (SD) of car speed was 79.4 (23.9) km/hr, 63% were higher than the legal speed limit (70 km/hr in urban areas, 110 km/hr on national highways , and 120 km/hr on expressways).

Factors related to location and time of injury

Majority of traffic-related injuries occurred on highways and streets (81%), 9% off road, 7% around homes in residential areas, and 3% in other locations. Forty one percent of pedestrians and 38%of motorcyclists were injured in the residential areas. There was no significant association between place of accident and mortality (P=0.39)Í
Evening (8pm–2am) was the most common time of crashes (47%) and Saturday-Sunday was the most common day of crashes (31%). The time of accident was not significantly related to mortality (P=0.51)

Factors related to Safety equipment, distraction, sleep and alcohol

Only 13% of the drivers, and 7% of front seat passengers were restrained. The failure to wear safety gear was significantly associated with mortality (P=0.00) which is a matter of grave concern in the society. No back seat passenger used a seta belt. Only 19% of motorcyclists used a helmet. 6% of drivers were using mobile phones and 116 drivers (5.49%) were sleepy. Alcohol use was found in 78 patients. Alcohol consumption was not significantly associated with increased mortality (P = 0.52).

Factors related to Severity and anatomical location of injuries

There were 465 patients admitted to the ICU. The median GCS was 14 (range 4–15), median ISS was 57 (range 1–40), median RTS was 11 (range 8–12) and median total hospital stay was 5 days (range 0–87).
The head was the most common injured region (71%) followed by extremities and chest. Major trauma or poly-trauma (ISS>15) was observed in 1352 patients. This group had a higher mortality rate than those with an ISS<15 (P<0.001).

DISCUSSION

Youth is the active period of life with major developments affecting adult health. Traffic-related injuries are the most common cause of morbidity and mortality in the youth. In our study, young males were at higher risk of being injured in traffic. Rollover crash was common with a high risk of ejection. Restraint use was extremely low in our study population. This age group is more often involved in vehicular crashes, while the older age groups usually suffer from pedestrian injuries in RTAs (Cunningham, 2001).
Fewer accidents were noted during the daytime. Although mortality was higher in nighttime RTAs, we did not observe a significant association between death and time of accident. Mishra et al. (2010) have also demonstrated that fatal RTAs are more likely to occur at night. This is probably due to nighttime being associated with empty roads, a temptation to speed, decreased driver awareness, substance abuse, fatigue, and poor street lighting. An implication of this finding is that emergency response services need to be available around the clock.
Fitzharris et al. (2009), in a study of urban India, showed that the failure to correctly wear a helmet led to a five-times greater likelihood of intracranial injury, and that as many as 84% of pre-hospital deaths occurred in two-wheeler riders not wearing helmets. Seat belt use remained low in our study which poses a serious threat to all vehicle occupants. Abuzidan et al. 2015 notes that there is a high risk of severe injury and fatality for unrestrained passengers, especially in front collisions and rollovers.
Rollover crash was the most common crash mechanism in our study with 9% of the passengers being ejected. Vehicles tend to roll-over during collision, because they have a higher center of gravity. Distractive driving is a major contributing factor for traffic collisions. US Transportation Department

reported that nearly 20% of all crashes involve some distractive driving (NHTSA, 2010). Distractive driving causes impairment in driving performance and prolongs reaction time (WHOÍ 2011). In our study, 6% of drivers were using mobile phones when they crashed.

Pre-hospital emergency services in developing nations are either not available or are largely under-utilized. Developed countries have managed to achieve reduced morbidity and mortality related to trauma by providing prompt and appropriate pre-hospital care (Kristiansen T, 2010) whereas in developing countries, studies show delayed transfers to hospitals and inadequate pre-hospital care (Paravar M, 2013). Further research in this regard should be encouraged.

CONCLUSION

We were able to identify a few factors related to increased youth traffic related traffic accidents in Western India. A lack of respect for the law, weak legislation and law enforcement, disregard for personal safety, and driving vehicles under adverse conditions are some of the leading causes of road traffic accidents. There must be an emphasis on emergency trauma care in the pre-hospital setting, as early transport of the injured patient to a hospital offers the best chance of survival. Ultimately, road traffic accidents can truly be reduced when individual maturity regarding road-safety practices is attained.

NOVELTY/TRAFFIC SAFETY IMPLICATIONS

Interventions in Traffic Routing Administration (TRA) are broad-based and include regulation, legislation and community projects. Governments, International agencies, civil society organizations, and private companies from more than 100 countries have launched the Decade of Action for Road Safety 2011-2020. India is also a committed partner in this campaign which seeks to save 5 million lives over the 10-year period.

The novelty of our study lies in the fact that this study is fairly representative of the urban setting in India and probably of the developing world.

As a personal responsibility, individuals must avoid driving while under the influence of alcohol, while excessively sleepy or fatigued, or during any sort of mental agony. Vehicles must be equipped with safety gear, such as seatbelts and airbags. Wearing helmets while on two-wheelers should be made mandatory, and failure to comply should be penalized.

ACKNOWLEDGEMENTS

This study is self-funded. Dr. Muntazir Sayed, MD and Kaneez Sayyada assisted in Statistical Analysis on the study.

REFERENCES

Abu-Zidan FM, Abbas AK, Hefny AF, Eid HO, Grivna M. Effects of seat belt usage on injury pattern and outcome of vehicle occupants after road traffic collisions: prospective study. World J Surg. 2012;36:255–9.

Cunningham C, Howard D, Walsh J, Coakley D, O'Neill D. The effects of age on accident severity and outcome in Irish road traffic accident patients. Irish Medical Journal: 94(6): 169-171, 2001.

Fitzharris M, Dandona R, Kumar GA, Dandona L. Crash characteristics and patterns of injury among hospitalized motorised two wheeled vehicle users in urban India. BMC Public Health: 9-11, 2009.

Kristiansen T, Soreide K, Ringdal KG, Rehn M, Kruger AJ, Reite A, et al. Trauma systems and early management of severe injuries in Scandinavia: review of the current state. Injury: 41 (5): 444-452, 2010.

NHTSA (National Highway Traffic Safety Administration). Distracted driving 2009. In Traffic Safety Facts – Research Note. 2010. http://www-nrd.nhtsa. dot.gov/Pubs/811379.pdf. Accessed 01 April 2024.

Paravar M, Hosseinpour M, Salehi S, Mohammadzadeh M, Shojaee A, Akbari H, et al. Pre-hospital trauma care in road traffic accidents in Kashan, Iran. Archives of Trauma Research: 1(4):166-171, 2014.

WHO. World Report on Road Traffic Injury Prevention: Summary. Geneva: World Health Organization: 1-52, 2004.

WHO. Global Status Report on Road Safety 2018; World Health Organization: Geneva, Switzerland, 2018. Available online: https: //www.who.int/publications/i/item/9789241565684 (accessed on 28 March 2024)

WHO. Road Injury Traffic. 2020. Available online: https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries (accessed on 26 March 2024).

WHO. Mobile phone use: a growing problem of driver distraction. Geneva, Switzerland, World Health

Organization. 2011. file:///C:/Users/m.grivna/Documents/1UAEU/2Publications/Journals/Youth%20injuries/References/ 2011%20WHO%20-%20NHTSA%20-%20Mobile%20phone%20use%20-%20A%20growing%20problem%20of%20driver%20distraction.pdf. Accessed 01 April 2024.

Maurer A, Morris JA Jr. Injury Severity Scoring. In: Moore E, Feliciano D, Mattox K (eds) Trauma (5th ed.), McGraw-Hill Companies, Inc, New York. 2004. p. 87-91.