TRIPP BULLETIN

VOL 8. NO.2 MONSOON 2011

TRANSPORTATION RESEARCH & INJURY PREVENTION PROGRAMME

INDIAN INSTITUTE OF TECHNOLOGY DELHI

Ph.D. Scholars *Current*

Highway safety
Scholar: Amit Agarwal
Supervisor: *G. Tiwari*

Economic impact of subsidies for public transport
Scholar:Ashwini Kumar Vaishnaw
Supervisors: *V. Upadhyay and G. Tiwari*

Heat transfer characteristic in helmets
Scholar:Bhagwat Singh Shishodia
Supervisors: *S. Sanghi and P. Mahajan*

Traffic flow and risk analysis in mixed stream
Scholar: Gaurav Pandey
Supervisor: *R.R. Kalaga*

In-vivo measurement of constitutive properties
Scholar: Hemant N Warhatkar
Supervisors: *A. Chawla and S. Mukherjee*

Demand models for bicycle traffic integrating landuse parameters
Scholar: Himani Jain
Supervisor: *G. Tiwari*

Pedestrian behaviour modeling
Scholar: Mariya Khatoon
Supervisors: *N Chatterjee and G. Tiwari*

Study of bone fracture characteristics
Scholar: Mike W J Arun
Supervisors: *A. Chawla and S. Mukherjee*

Institutional and regulatory structure for providing urban public transport
Scholar: O.P. Agarwal
Supervisors: *G. Tiwari and V. Upadhyay*

Safety considerations in bicycle demand models
Scholar: Pankaj Prajapati
Supervisor: *G. Tiwari*

Estimation of externalities in public transport system
Scholar: Pradeep Singh Kharola
Supervisors: *G. Tiwari and A. Kanda*

Transportation planning and environment
Scholar: P.V. Pradeep Kumar
Supervisor: *S.R. Kale*

Evaluation of road infrastructure for pedestrian safety
Scholar: Shalini Rankavat
Supervisor: *G. Tiwari*

Service level benchmarks for urban transport systems
Scholar: S K Lohia
Supervisors: *V. Upadhyay and G. Tiwari*

Impact of informal landuse on travel demand
Scholar: S.S.L.N. Sarma
Supervisor: *G. Tiwari*

Road traffic injury prevention and highway safety
Scholar: Sumeet Gupta
Supervisor: *G. Tiwari*

Ph.D. Scholars *Completed*

Tool for positioning human body FE model
Scholar: Dhaval Jani
Supervisors: *A. Chawla and S. Mukherjee*

M.Tech. Projects *Completed*

Financial operational and safety performance of bus system: Case study DTC
Student: Abhijit Ghosh
Supervisor: *G Tiwari*

City specific driving cycles for different modes in Delhi city
Student: Aloy Nag
Supervisors: *G. Tiwari and Kalaga R R*

Trip generation forcasting model Patna city
Student: Muslihuddin Jahed
Supervisors: *Kalaga R R and G. Tiwari*

Bus route rationalization
Student: Mahesh Kumar Raman
Supervisor: *Kalaga R R*

Finite element analysis of geosynthetic reinforced flexible pavement
Student: Satish Pandey
Supervisors: *Kalaga R R and Devish Tiwari*

Parking regulations and demand assessment
Student: Tapas Biswas
Supervisor: *G. Tiwari*

Optimization of geometric design and alignment of highway
Student: Vaishali Kaul
Supervisors: *Kalaga R R and G. Tiwari*

Comparison of environmental impacts by different technologies of bituminous road resurfacing, on the basis of Life Cycle Assessment
Student: Vivek Arora
Supervisors: *G. Tiwari, Kalaga R R and Kirti Bhandari*

B.Tech. Projects *Completed*

Design and fabrication of a rig to test shoulder complex ligaments
Students: Kartik Marwah and Lucky Grover
Supervisors: *A. Chawla and S. Mukherjee*

Assessment of pedestrian risk at foot of flyover in an urban area
Student: Surabhi Bhandari
Supervisor: *G. Tiwari*

Road safety of pedestrians in Delhi
Student: Mugdha Saxena
Supervisor: *G. Tiwari*

Pedestrian safety
Student: Sanjeev Tank
Supervisor: *G. Tiwari*

Pedestrian risk assessment (at zebra crossings)
Student: Mittali Bhandari
Supervisor: *G. Tiwari*

Network assignment model for bicycles based on bicycle compatibility concept for Pune, India
Student: Karan Gupta
Supervisor: *G. Tiwari*

Determinants of bicyclists route-choice case of Pune city, India
Student: Ashish Bhatia
Supervisor: *G. Tiwari*

The **Transportation Research and Injury Prevention Programme (TRIPP)** at the Indian Institute of Technology Delhi, is an interdisciplinary programme focussing on the reduction of adverse health effects of road transport. TRIPP attempts to integrate all issues concerned with transportation in order to promote safety, cleaner air, and energy conservation. Faculty members are involved in planning safer urban and inter-city transportation systems, and developing designs for vehicles, safety equipment and infrastructure for the future. Activities include applied research projects, special courses and workshops, and supervision of student projects at postgraduate and undergraduate levels. Projects are done in collaboration with associated departments and centres at IIT Delhi, government departments, industry and international agencies.

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Now a consultant on highway safety issues, Allan Williams was former Chief Scientist at the Insurance Institute for Highway Safety, Washington DC, USA

PUBLIC INFORMATION AND EDUCATION (PI & E) PROGRAMS AND TRAFFIC SAFETY

Why do policy makers depend so heavily on public information and education (PI & E) programs to control road traffic injuries and what is the evidence regarding the effectiveness of these programs?

Public information programs are typically referred to as mass media programs, because that is the usual mode of delivery, through television, radio, the internet, and print. Most education programs involve direct, face-to-face contact with a specific audience. Both types of programs have been used extensively in the highway safety field. PI & E programs have a valuable role to play. For example, they can help to set the public agenda, establishing the issue as one of concern, providing support for addressing it, and augmenting the effects of laws and other measures. However, PI & E programs are often used as stand-alone efforts in an attempt to change individual behavior, and they have had very limited success in doing so. Despite this record, their use for this intended purpose remains very popular with policy makers and the general public.

There are reasons for this popularity. Almost all motor vehicle crashes involve some degree of driver error, and the link between driver behavior and crashes is clearly and immediately apparent. In other health areas, such as tobacco use, the relationship between the behavior and unwanted health outcomes is more distant and remote. The obvious link between human behavior and crashes is one reason there has always been emphasis on changing driver behavior. We know as well the behaviors that facilitate avoiding crashes: paying attention, obeying traffic laws, driving "defensively," not driving when fatigued or impaired by alcohol or other drugs. We want drivers to behave in these ways so they do not endanger the rest of us who share the roads with them, which spurs driver behavior change programs. The assumption of PI & E programs is that if individuals are made aware of behaviors that will enhance their personal health and safety, and urged to adopt these behaviors to protect themselves and others, they will do so. Although seemingly logical, this sequence of events typically does not happen, for reasons to be discussed.

One example of the continuing popularity of PI & E programs comes from the United States, where in an analysis of behavioral countermeasures used by states, 38 of the 104 measures entailed voluntary actions, primarily PI & E. This was the largest category, followed by laws (30), laws plus enhancements (18) and sanctions and treatments (18). However, only 16% of the voluntary actions measures were judged to be likely or proven effective at changing behavior, compared with 53% of the laws, 72% of the laws plus enhancements, and 67% of the sanctions/treatments.

In the highway safety area, there are effective ways outside of individual behavior change to reduce crashes or their consequences through vehicle design enhancements and sound engineering/environmental practices. However, PI & E programs remain dominant. Exhorting people to take some preferred health action for their own benefit is easy to do and gives the appearance of doing something important for society; sometimes these efforts are referred to as "feel-good" programs. A somewhat cynical portrayal of this situation was offered by David Stone of Glasgow University in an article titled,"Upside Down Prevention." Stone noted that human health behavior is "notoriously resistant to well intentioned attempts to alter it", and that socio-environmental engineering is recognized by public health experts as the most efficacious form of health promotion. He concluded that official support for different approaches to health promotion is given in inverse proportion to their effectiveness, commenting that "socio-environmental change is costly, radical, and unpredictable, and therefore to be avoided, while health education is cheap, generally uncontroversial, and safe: if it works, the politicians take the credit, and if it does not, the target population takes the blame for not responding."

Why is road user behavior difficult to change?

One reason this task is difficult is that safe driving practices and protective behaviors such as seat belt use have to be done on each trip, so programs that have only short-term effects are basically useless. In this regard, PI & E programs are at a disadvantage since they are generally not ongoing, often coming in the form of campaigns or short, one-time programs. Even if some PI & E programs succeed in improving behavior at one point in time, making this change permanent is a more difficult challenge. On the other hand, laws and environmental alterations, once in place, can be expected to have enduring effects, since their presence is constant.
One barrier to behavior change through PI & E programs is that most people know full well how they are supposed to behave on the highways and why they should do so. It is not a matter of lack of knowledge. What people actually do is determined by attitudes, motivations, lifestyle factors, influence of peers, and assumptions about risk. Experienced drivers have well-developed habits that are not easy to change.

A second factor is that we know from risk perception research that in very familiar activities like driving, there is the tendency to minimize the possibility of bad outcomes as a way of allaying personal concerns. People underestimate the risks that are supposed to be under their own control. This sense of personal immunity is buttressed by the tendency of most people to think their own driving skills are above average, a finding from research studies around the world. Crashes happen, but to other drivers; the highway safety problem in the view of many people is a problem of the "other" driver. In this context, safety messages are viewed as being for these others, not ourselves.

It is also notable that serious crashes are extremely rare events. Speeding, driving while impaired by alcohol or fatigue, running red lights, not using seat belts, and other dangerous and illegal behaviors generally have no downside. In this sense, drivers are rewarded every time they take a trip involving these actions.

All of these factors, taken together, pose significant barriers to influencing driver behavior.

How well have PI & E programs been evaluated?

One of the features of the highway safety field is that many programs have been adopted on the basis of common sense, and become embedded in societies without any evidence of their effectiveness. This is in sharp contrast with the introduction of measures for the alleviation of other public health problems.
Many PI & E programs in wide use around the world have not been

evaluated at all. In addition, many of the existing "evaluations" are deficient in scientific quality, typically simplistic "before-after" studies that dominated the early days of highway safety research. Such studies fail to control for factors that can influence any changes found, and often involve comparisons of a volunteer group with a non-self-selected one, which can lead to unwarranted conclusions.

The lack of competent evaluations is a serious drawback. Unevaluated programs cannot contribute to the science of behavior change programs. The present state of affairs allows for the possibility that programs that do not work as intended continue to operate, taking money and energies away from programs known to work. Moreover, although it may be assumed that programs that do not work at least will do no harm, some programs when formally evaluated have been found to have negative outcomes. For example, a bicycle education program in Australia produced negative effects, probably by inadvertently encouraging risk taking.

What have we learned about what PI& E programs can accomplish?

When adequate evaluations have been done, it is not difficult to find examples of programs that have either had no effects or short-term effects that dissipate quickly. This is the case for both education programs and public information or mass media programs, and for both highway safety behavior and behavior in other health realms. In some cases where there have been positive effects, costs are high and the effects modest. For example, an intensive public information program in Greece increased seat belt use but the gain was only from 5 percent to 10 percent, at a cost of three million U.S. dollars, and it is not known if this small increase was maintained after the program was discontinued.

One area in which PI & E programs can be successful is when there is "new" knowledge. The best example comes from the United States, involving the changeover in child seating positions in vehicles to avoid air bag inflation dangers. The dramatic shift of children from front to rear seats was largely driven by public information programs. New knowledge is also a factor that can make the behavior of children easier to influence than that of adults. In the United States elementary school training programs have been found to decrease pedestrian crashes. However, the evidence for other approaches to child pedestrian safety, such as child safety clubs, is unclear.

PI & E programs vary in both type and quality, and in assessing their potential contribution it is important to differentiate among programs. In regard to public information programs, many have been of poor quality, consisting of passive messages communicated by signs, pamphlets, brochures, and buttons; use of slogans that give people simple exhortations to behave in certain ways to avoid undesirable outcomes; and programs delivered to an undifferentiated audience over the short term. Highway safety messages conveyed in these ways may increase awareness of the health issue being addressed and reinforce social values, but are unlikely to have any effect on behavior. Higher quality public information programs involve careful pre-testing of messages, delineation of the target group, and making sure the messages reach the target group and are delivered in sufficient intensity over time. Even with this more sophisticated approach, however, long-term behavior change is difficult to achieve when this is the lone program element.

Similarly, education programs vary in ways that can make a difference. Didactic programs delivered in lecture format are at one end of the spectrum. Typically these programs provide information and often use a fear approach in trying to motivate people to take action, emphasizing the statistical likelihood of being in a crash, or the damage to self and others that can result. Recipients of these messages can deflect them, but the vast literature on fear techniques indicates that they work best when fear is combined with concrete steps people can take right now to avoid the danger (as in the case of moving a child to the rear seat to avoid air bag inflation injuries). Too often, however, fear has been combined with low-efficacy generalized messages, for example, "drive defensively." A special type of fear message is popular in the United States in dealing with adolescents, using extreme scare tactics featuring fake deaths, mock death notifications, and mock funerals. Programs of this type have been referred to as "health terrorism," and are unlikely to work, other than producing a short-term emotional response. Adolescents are particularly likely to react to severe threats by discounting the likelihood that they themselves will be involved. Moreover, risk has attractions for young people and they are likely to assess risk in terms of opportunity for gain rather than for loss. Focus groups have indicated that young drivers are tired of fear messages, have heard it all before, think these messages are condescending, and are inured to shock messages given the media they are routinely exposed to.

Other education programs, which might be more aptly called persuasion or influence programs, have been based on theoretical models of behavior change, such as protection motivation theory, or the theory of planned behavior, or use interactive methods to teach skills to resist social influence through role playing, behavioral rehearsal and group discussion. Even these more theoretically grounded programs, however, are not necessarily able to change behavior successfully.

The lesson learned is that PI & E programs can best contribute to behavior change by combining with other elements, as a part of broader-based community programs, or in support of law enforcement. There have been several programs that have successfully induced behavior change through focused efforts involving a coalition of community groups. Program activities typically involve a broad range of groups, including health care professionals, educators, law enforcement, government agencies, private industry, and service clubs. Programs in the United States successfully increasing booster seat use and child bicycle helmet use have included both educational and public information efforts, considered essential in making known the rationale, goals, and activities of the campaigns, keeping the campaign in the limelight, and reporting on progress.

The classic example of a positive contribution of PI & E programs to behavior change in the United States is when they are combined with enhanced law enforcement efforts, especially in regard to seat belt use. "Click it or Ticket" programs have flourished and are credited with bringing seat belt use in the United States closer to levels achieved internationally. It is well established in the research literature that enforcement alone is not sufficient in increasing belt use, but when enforcement campaigns are combined with intensive publicity about the enforcement, there have been major gains in belt use. Surveys have indicated that even non-users think it is wise to use belts, but educational programs that accompany "Click it or Ticket" efforts and emphasize the importance of using belts solidify public support for the stepped-up enforcement.

How would you summarize the role of PI & E programs?

PI & E programs have been very popular and used extensively in the highway safety field. Such programs may reinforce social values, but they are unlikely to change behavior. Used alone, even high-quality programs have had little success in changing individual behavior, and when they do the effects are typically modest and not necessarily long lasting. PI & E programs best contribute to behavior change, and play an essential role, when combined with other ongoing prevention activities, in support of law enforcement, or as one element of broader-based community programs. Notably, many successful behavior change programs are one-time events applied to a single community, or other discrete populations, which limits effects. This contrasts with policy-level changes such as taxes, laws, and environmental changes that apply permanently to wider populations once instituted. Money allocated to PI & E programs should be spent on those shown by research to contribute to behavior change, but PI & E programs also have an important role in promoting effective policies that have permanent effects on the population as a whole.

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SYSTEMATIC REVIEWS OF LITERATURE ON PUBLIC INFORMATION AND EDUCATION (PI & E) PROGRAMS AND TRAFFIC SAFETY

Source: Cochrane Injuries Group

The Cochrane Injuries Group editorial base is located at the London School of Hygiene & Tropical Medicine in the UK (http://injuries.cochrane.org).

Cochrane Reviews are systematic reviews of primary research in human health care and health policy. They investigate the effects of interventions (literally meaning to intervene to modify an outcome) for prevention, treatment and rehabilitation. All the existing primary research on a topic that meets certain criteria is searched for and collated, and then assessed using stringent guidelines, to establish whether or not there is conclusive evidence about a specific treatment. These strategies include a comprehensive search of all potentially relevant studies and the use of explicit, reproducible criteria in the selection of studies for review. Cochrane Reviews are internationally recognised as the highest standard in evidence-based health care.

Campaigns to encourage children to wear cycle helmets usually work, but some work better than others

Many children suffer head injuries while riding a bike. The review focused on encouraging children to wear helmets, as distinct from compelling them to do so through laws. The reviewers wanted to find out which sort of campaigns work best - particularly with children from poor families, who are less likely to own helmets. They found 22 helmet promotion campaigns that had been studied. The campaigns varied widely with regard to where they were carried out, age of the children, campaign methods etc. The results were also very varied but overall, after a campaign, children were more likely to wear helmets than other children. More research is still needed but it seems likely that the best schemes are based in the community and involve both education and providing free, or possibly subsidised, helmets. Promotion of helmets in schools also seems to be effective. The reviewers could not identify the best way of reaching poorer children. The studies they reviewed did not look at the impact of the campaigns on injury rates, or assess whether the promotion campaigns had any negative effects.

Motorcycle rider training for preventing road traffic crashes

Riders of motorcycles (a two-wheeled vehicle that is powered by a motor and has no pedals - Oxford English Dictionary Online), especially novice riders, have an increased risk of being involved in fatal crashes compared to other road users. Motorcycle rider training could be an important way of reducing the number of crashes and the severity of injuries.

The authors of this review examined all research studies that report an evaluation of the effectiveness of motorcycle rider courses in reducing the number of traffic offences, motorcycle rider crashes, injuries and deaths. This review included 23 research studies, including three randomised trials, two non-randomised trials, 14 cohort studies and four case-control studies. The types of rider training that were evaluated varied in content and duration. The findings suggest that mandatory pre-licence training may present a barrier to completing a motorcycle licensing process, thus possibly indirectly reducing crash, injury, death and offence rates through a reduction in exposure to riding a motorcycle. However, on the basis of the existing evidence, it is not clear if (or what type of) training reduces the risk of crashes, injuries, deaths or offences in motorcyclists and the selection of the best rider training practice can therefore not be recommended.

It is likely that some type of rider training is necessary to teach motorcyclists basic motorcycle handling techniques and to ride a motorcycle safely. It is therefore important that further research work be conducted to rigorously evaluate motorcycle rider training courses, particularly in low income countries where the main burden of motorcycle injuries and deaths occur.

Pedestrian safety education for children can improve their knowledge and change their road crossing behaviour, but effects on injury are unknown

A major proportion of the people killed or seriously injured in road traffic crashes are pedestrians, and children are particularly vulnerable. Education programmes try to teach people how to cope with the road environment. Parents are sometimes used as educators. The review of trials (mostly in children) found that pedestrian safety education can improve children's road safety knowledge and their observed road crossing behaviour. Education may need to be repeated at regular intervals, as the effect can decline with time. However, whether these changes to knowledge or behaviour can be linked to a reduction in pedestrian deaths and injuries is unknown.

Strong evidence that advanced and remedial driver education does not reduce road traffic crashes or injuries

Road traffic crashes are a major cause of death and injury worldwide. As drivers' errors are a factor often contributing to traffic crashes, driver education is often used in the belief that this makes drivers safer. Driver education for licensed drivers can be remedial programmes for those with poor driving records, or advanced courses for drivers generally. They can be offered by correspondence, in groups or with individualised training. The review of trials found strong evidence that no type of driver education for licensed drivers leads to a reduction in traffic crashes or injuries.

School based driver education leads to early licensing and may increase road crash rates

Teenagers have a higher risk of road death and serious injury than any other group. School based driver education has been promoted as a strategy to reduce the number of road crashes involving teenagers. The results of this systematic review show that driver education in schools leads to early licensing. They provide no evidence that driver education reduces road crash involvement, and suggest that it may lead to a modest but potentially important increase in the proportion of teenagers involved in traffic crashes.

Course Announcement

The Transportation Research and Injury Prevention Programme (TRIPP) at the Indian Institute of Technology Delhi, is organizing an eight day **"International Course on Transportation Planning and Safety"**. The course will be held in New Delhi, India, from 5 - 12 December 2011. The course will have a common component for the first three days, followed by two parallel modules on Traffic Safety and Biomechanics and Crashworthiness.

Details of the course can be accessed from -http://tripp.iitd.ernet.in

Establishment funds have been received from
Ministry of Industry, Government of India
Asian Institute of Transport Development, India
Tata Motors, India
Volvo Research and Educational Foundations(VREF), Sweden

Endowments for perpetual Chairs
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Excerpts from a Ph.D. Dissertation

Title: Repositioning the knee and the hip joints in human body finite element model for impact simulations

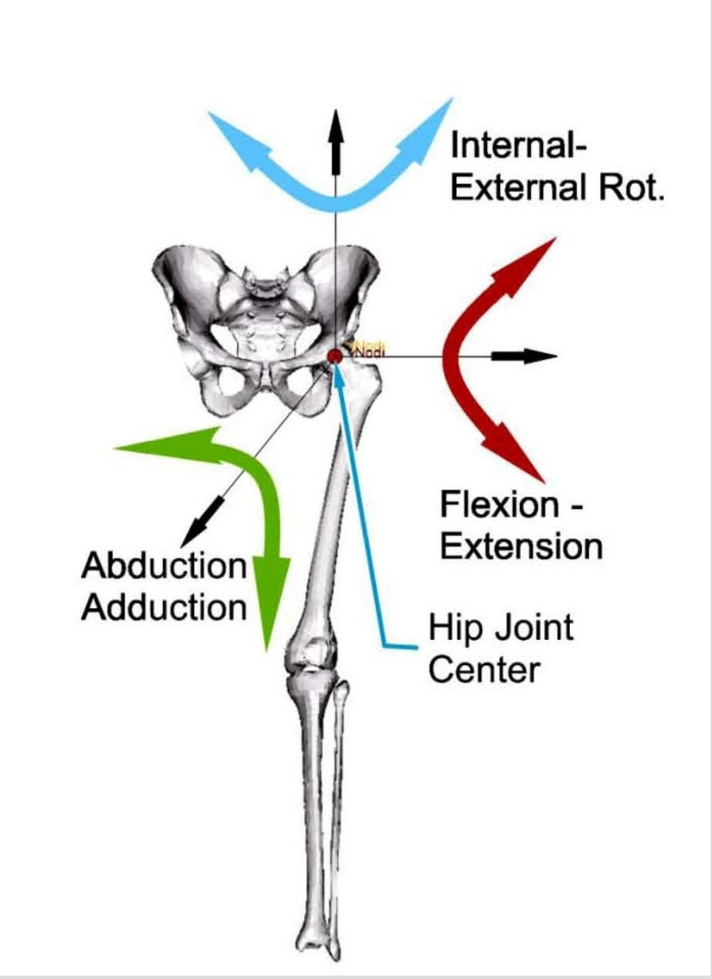
Scholar: Dhaval Ashvinkumar Jani

Supervisors: Anoop Chawla and Sudipto Mukherjee

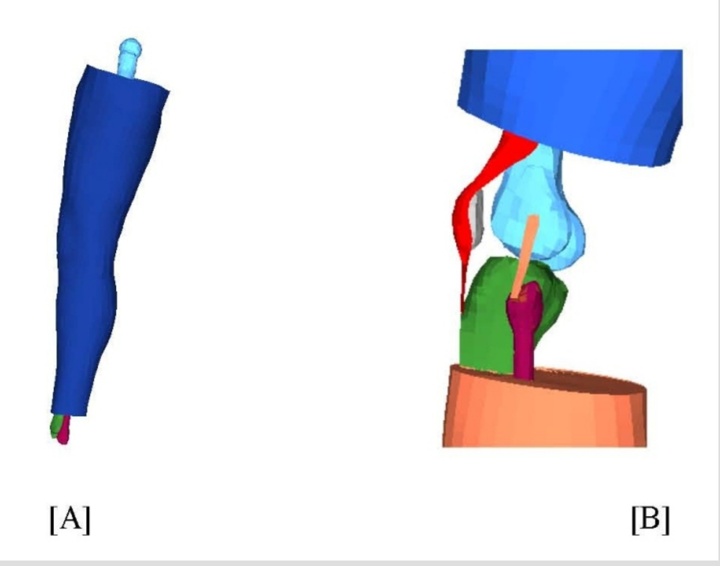
Department: Mechanical Engineering Department

Abstract:Human Body Finite Element Models are capable of providing a comprehensive understanding of human impact response, injury mechanism and human tolerances. An accurate estimation of the effect of interaction of body parts is possible only if the model being used for the simulation is reoriented to a range of postures representative of humans in real life. The present thesis contributes to the development of a methodology for repositioning human body models and demonstrated on the knee and the hip joint of human body finite element models. A methodology based on geometrical transformations and mesh mapping has been coded in Visual C++ and OpenGL®. While elemental volume is preserved during repositioning, a mesh smoothing algorithm manages mesh quality. Time taken to reposition to postures configurable with the knee joint and hip joint is of the order of a minute. Stability and suitability of the repositioned model for dynamic finite element simulations, evaluated for impacts on different regions have been used to establish robustness of the algorithm. Variation due to knee flexure, hip abduction and adduction show significant differences in terms of reaction forces and estimates of injuries sustained from orthogonal foam-cushioned impacts. An efficient method to reposition the knee joint and hip joint of human body finite element model has been developed and demonstrated. The method allows control over the bone kinematics to ensure the anatomical consistency of the posture produced. Repositioned models are suitable and stable for dynamic finite element simulations without mesh editing.

Introduction: Increasing mobility has resulted in an increase in causalities in road traffic crashes. Road traffic injuries are among the second to sixth leading cause of death in the age group 15-60 years in all countries of the Southeast Asia region (Mohan 2004). Mohan (2009) has reported that in India, the total number of road traffic fatalities increased at an average rate of about 4% per year in the period 1997-2003 and the rate has increased to 8% per year since then. In the absence of preventive actions, it is possible that India will have 150,000 – 175,000 road traffic fatalities in the year 2015 (Sundar et al. 2007). Injuries due to road accidents are a problem but these can be reduced considerably if adequate attention is given to accident and injury prevention strategies. Passive safety is a relatively low cost measure that has proven to be an effective method for the reduction of crash related trauma (Vezin et al. 2005). Research on vehicle safety over the past three decades, especially in the Organization for Economic Co-operation and Development (OECD) countries has led to design of safety devices and features for protecting the occupants from major injuries and fatalities (Mukherjee et al. 2007). This has been possible because numerical modeling during the design and evaluation allows many more iterations than possible during purely experimental processes. The versatility and efficiency of computational modeling of manufactured parts has in turn demanded a new paradigm, Finite Element (FE) based human body models to predict injuries and describe injury mechanism. This is being projected as the preferred



The hip joint and motion at hip joints



(A) GM/UVA model in initial configuration
(B) Detailed view of the knee joint region of GM/UVA model

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Continued from overleaf:

method of achieving significant reductions in road traffic injury and fatality. To control injuries originating from road crashes, it is essential to develop a system to predict the injury in possible scenarios. Over the years, methods used by researchers to predict injuries include cadaver tests, volunteer and animal tests, Anthropometric Test Devices (ATD, popularly known as dummies) and human body finite element models (FE-HBMs). Among the systems above, FE-HBMs are becoming more acceptable and hence increasingly used for virtual testing with their improved biofidelity and cost effectiveness. In the last decade, many human body finite element models (THUMS (Maeno et al. 2001), HUMOS2 (Vezin et al. 2005) and JAMA/JARI (Sugimoto et al. 2005) to name a few) have been developed. The geometry of most of these models is limited only to standard occupant or pedestrian postures. However, in real life, the body can be in various postures such as standing, walking, running or jogging postures and out-of-position occupant postures. Compromises due to non-availability of FE models for these variations may lead to erroneous conclusions and may limit the use of these models. On the other hand developing FE models for all possible limb positions is not viable. Therefore, reconfiguration of existing FE models to get Posture Specific Human Body Models through limb adjustments needs to be set up. The aim of this thesis is to develop a methodology to reposition human body finite element model lower extremity (knee joint and hip joint). The methodology is implemented through a code developed using VC++. Repositioning of the knee joint and the hip joint (joint between coxal and femur) of an existing human body finite element model has been carried out. In order to ensure the suitability of the model for subsequent simulations, mesh quality is preserved to the level of the initial model. With the method developed, models depicting various postures can be produced within few seconds without compromising their mesh quality and numerical stability. The ability of method to facilitate, incorporation of available anatomical information about bone kinematics and soft tissue deformations as well as postural consistency of the repositioned models is ensured.

A method has been developed to reposition human body finite element models. Application of the method has been successfully demonstrated on the hip joint and the knee joint of an existing human body finite element model. Models were repositioned to acquire different postures within few seconds while maintaining mesh quality and numerical stability:

1. The results have demonstrated the capability of the method proposed to reposition the human body FE model in a minute on a desktop computer.

2. The method does not require dynamic FE simulations and runs very fast;it takes of the order of a minute to transform a model to a desired posture.

3. The method is capable of incorporating known bone kinematics and soft tissue deformation data.

4. The method allows transitions to anatomically precise positions.

5. The mesh quality of the repositioned model is programmatically managed and does not require any manual mesh editing.

6. The method does not alter the nodal connectivity information.

7. The repositioned models are suitable for FE simulations in new posture without manual intervention.

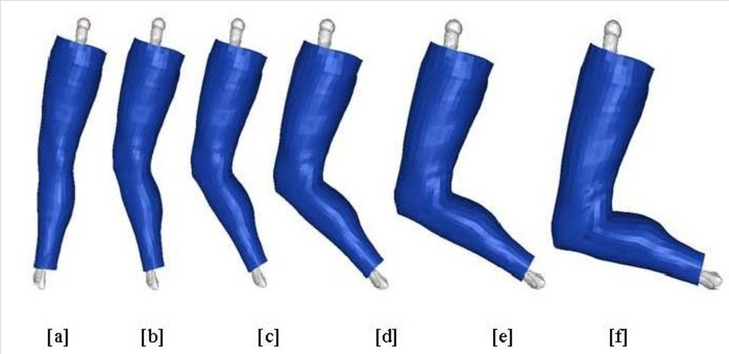
8. The process of repositioning produces the same output when similar transformations are done consecutively.

9. The mesh smoothing technique developed is suitable for general structured as well as unstructured hexahedral meshes.

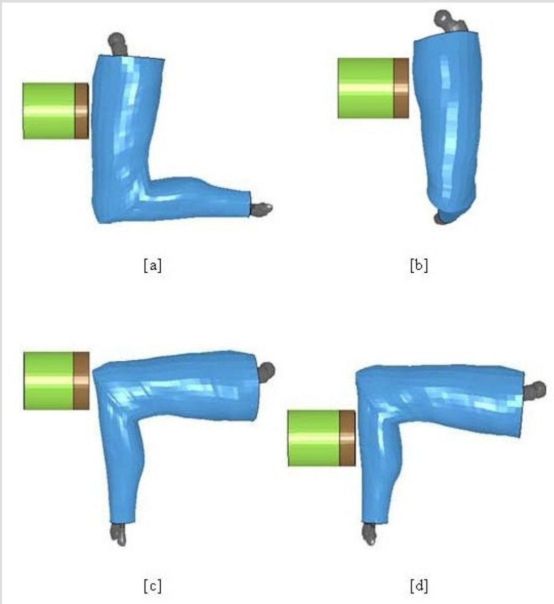
10. Numerical stability of repositioned models has been evaluated by subjecting them to a series of simulations.

11. The need of postural accuracy in FE-HBM has been demonstrated. It was found that, the variations of the peak forces and injuries sustained were significantly different in case of impact with hip abduction or adduction.

Thus it can be concluded that an efficient method to reposition a FE - HBM has been developed and implemented for the knee and the hip joint. The gains over earlier methods are in time saving, anatomical correctness and stability of the repositioned model.



Lower extremity model (a) Initial configuration (~ 9o flexion) and flexed at: (b) 30o (c) 45o (d) 60o (e) 75o (f) 90o



Configurations for impact simulation of repositioned leg (a) Frontal Thigh (b) Lateral Thigh (c) Knee Flesh (d) Below Knee