Biomechanical Response of the Pediatric Ankle

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ABSTRACT

The goal of this study is to evaluate the anthropometric characteristics and dynamic response of the pediatric ankle by non-invasively measuring leg and ankle anthropometry, ankle range of motion, and ankle stiffness. While much of the attention has been focused on the pediatric head and thorax, upwards of 28% of injuries in frontal crashes are to the lower limb. As the foot-ankle-lower leg complex makes contact with the front row seatback, injuries to the tibial physes, tibial palfond, and talus are fairly common and very serious. The pediatric ATD's have no instrumentation below the knee making it impossible to evaluate the amount of force on impact or the amount of force traveling up the kinetic chain during frontal collisions. The recent testing of child interactions with knee bolster airbags also raised questions regarding the biofidelity of the lower extremities of the pediatric ATD's. The airbag tests revealed that the ankle joint should be of interest to researchers, as the foot is the first body part to interact in a frontal collision. Without a biofidelic ankle in the child ATD there is no way to directly measure these forces or accurately predict injury in the entire lower extremity. Children between the ages of 4-12 years were placed into 2 groups (n=20) to correspond with the 6 and 10 year old ATD's. Anthropometric measurements were taken bilaterally on the foot, ankle, and leg. Range of motion (ROM) measurements were taken in plantar and dorsiflexion, inversion and eversion in a neutral position, and inversion and eversion of the rear foot. Both active and passive ROM was measured with a handheld goniometer. Ankle stiffness measurements were measured using an Isokinetic Dynamometer (Biodex System III, Biodex Medical Systems, Inc. Shirley, New York). Stiffness measurements were taken in all 6 motions. Each subject completed 1 set of 4 repetitions at 5°/sec., followed by 1 set of 5 repetitions at 30°/sec, and a third set at 60°/sec. in PF/DF and both INV/EV positions. The degrees and torque values were recorded throughout the entire ROM. Subjects were instructed to push against the dynamometer as it moves through the ROM. Anthropometry showed growth form Group 1 to Group 2. Average ROM was determined for each group. ROM analysis revealed multiple significant between group differences primarily in active and passive DF mostly involving the left ankle. Dynamic data reveal between group differences in torque generation in PF and DF. The information gained from this study will benefit the automotive industry by providing critical information necessary to produce a more biofidelic ankle in the 6 and 10 year old ATD's, with the goal of increasing vehicle and car seat safety for children. The biomechanical data will also provide beneficial information to the rehabilitation community working with children with gait abnormalities and spasticity disorders, such as cerebral palsy.

INTRODUCTION

Motor vehicle accidents (MVA's) account for an estimated 50% of pediatric trauma, with 15% - 28% resulting in lower extremity orthopedic injury (Brown e.al., 2006; Jermakian et al., 2007; Meier et al.,2005). The use of child safety seats can reduce the risk of fatality by 71% in infants and 54% for toddlers according to the National Highway Traffic Safety Administration (2008). There are numerous studies evaluating pediatric head, thorax, and abdominal injuries, which directly resulted in improvements to the pediatric ATD, as well as improvements in child safety seats. In both the adult and the pediatric population lower extremity injury is often reported second in prevalence only to head injury when discussing injury in motor vehicle accidents (Jermakian et al., 2007; Meier et al., 2005). Though lower extremity injuries are not life threatening, serious trauma to the foot-ankle-lower leg complex may occur, with some of the most severe injuries disrupting the epiphyseal plates.

As children are turned to the forward facing position, the child is prone to lower extremity injury as the legs collide with the seatback in front. Forces are then transmitted up through the ankle, tibia, knee, etc., especially in a frontal collision. As the foot-ankle-lower leg complex makes contact with the front row seatback, injuries to the tibial physes, tibial palfond, and talus are fairly common and very serious (James & Daigneault, 2000; Kay & Tang, 2001; Rhomiller et al.,2006; Ribbans et al., 2005; Seel et al., 2011). Some lower extremity injuries are missed while the child is in the Emergency Department (ED), due to evaluative focus on the head, thorax, and abdomen (Kay & Tang, 2001).

Another confounding factor for injury to the lower extremity involves improperly restrained or unrestrained children in MVA's (Brown, et al., 2005; Jermakian et al., 2007; Johnston et al., 1994). Studies evaluating child restraint misuse demonstrate an increase in morbidity and mortality for children in MVA's (Bulger et al., 2008). Brown et al. (2005) found a large increase in orthopedic injuries in the unrestrained population. Those sitting in the front seat were more likely to suffer thorax, abdominal, pelvis, and orthopedic injuries. This group also had the greatest percent of fatalities at 16.18%. Brown was also able to assess the protective value of seatbelts, decreasing the risk of orthopedic injury from 40% if unbelted to 15% if belted.

One of the most important anatomic differences between the child and the adult is the presence of physes and apophyses or growth plates. Primary ossification of the tibia, calcaneus, cuboid, talus, and phalanges often occurs by birth, however secondary ossification takes place later into childhood (Kay & Tang, 2001). The phalanges, metatarsals, and navicular often do not ossify until around 3 years, the calcaneus may not ossify until the age of 10 (Kay & Tang, 2001), and the distal tibial physes asymmetrically ossifies around the age of 14 (Sarraff & Haines, 2010). Delayed physeal closure and the inherent cartilaginous nature of the bone in this population may account for some of the variation in pediatric injuries, as infants and toddlers rarely have foot fractures (Kay & Tang, 2001).

Pediatric injury biomechanics of the lower extremity is an area in need of more research, to gain understanding of both low and high velocity trauma mechanisms, like those seen in MVA's. There has been significant advancement in the sophistication of the instrumentation in the adult anthropomorphic test devices (ATD's), but the pediatric population has not yet seen the same advancements; as the Hybrid III Adult male and female ATD's have instrumentation in the lower extremity, providing valuable data in frontal impact testing. Up to this point, little work has been done in the area of pediatric lower extremity injuries, due in part to a lack of sufficient instrumentation on pediatric Anthropomorphic Test Devices (ATDs). The pediatric ATD's have a simple clevis ankle, which does react realistically and therefore forces that are transmitted through the ankle may not be reflective of the actual event. The mechanisms of lower extremity injury are not clearly understood and there is no way to directly measure them.

The objective of this study is to evaluate the anthropometric characteristics, range of motion of the ankle, and dynamic ankle stiffness on pediatric volunteers between the ages of 4-12 years old. This data will be used to gain a better understanding of the characteristics and response of the pediatric ankle with the goal to develop a more realistic ankle on the pediatric ATD, which currently does not exist.

METHODS

Thirty children between the ages of 4-12 years old participated in this study. Subjects were divided onto two groups, Group 1: ages 4-7 years old and Group 2: ages 8-12 (Table 1). Group 1 corresponds to the 6 year old ATD, whereas Group 2 corresponds to the 10 year old ATD. No subjects had previous medical history of an ankle injury or surgery. Prior to participation all procedures were discussed with each subject and parent. Parental consent was obtained in accordance with the Institutional Review Board (IRB# 2011H0300) of The Ohio State University. All data was collected in one testing session in the Sports Biomechanics Laboratory at The Ohio State University.

Table 1: Subject Demographics (Mean ±SD)

Group	Total N	Gender	Average Age	Average Weight
Group 1: 4-7 years old	13	M = 5 F = 8	5.8 (1.0)	48.9 (10.2)
Group 2: 8-12 years old	17	M = 10 F = 7	9.2 (1.1)	80.4 (19.0)

Anthropometry Measurements

Anthropometry measurements were recorded for each subject following the NHTSA Test Reference Guidelines, Version 2, Volume 5 (2006). Additional measurements were used for comparison with Crandall et al. (1996). All data was measured bilaterally using appropriate anthropometry instruments (Rosscraft Innovations Inc). Only significant findings will be discussed in the paper, please see Appendix A for all measurements taken.

Goiniometry Measurements

A standard hand-held goniometer was used to measure plantar flexion, dorsiflexion, inversion, eversion, rearfoot inversion, rearfoot eversion of each subject. All motions were measured both actively and passively, except for the rearfoot motions, which were only measured passively. Plantar flexion and dorsiflexion were measured in both a straight leg and bent knee position to account for the potential interaction of the gastrocnemius muscle on ankle dorsiflexion. Goniometry techniques followed standard clinical guidelines (Norkin & White, 2009) and were measured by the same experienced clinician for every subject.

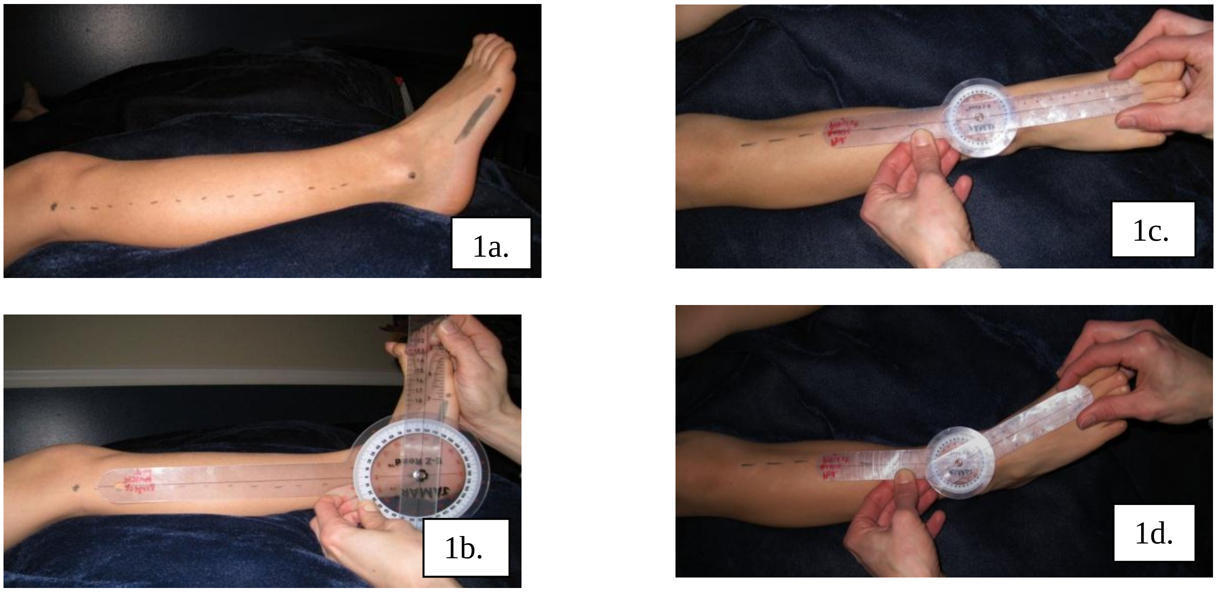

Figure 1. Technique and positioning for goniometry measurements. 1a. Bony landmarks for measuring plantar and dorsiflexion. 1b. Goniometry placement and start position for plantar and dorsiflexion measurement. 1c. Start position for inversion and eversion measurement. 1d. Positioning for inversion measurement.

Dynamic Stiffness Measurements

Dynamic ankle stiffness measurements were measured using an Isokinetic Dynamometer (Biodex System III, Biodex Medical Systems, Inc. Shirley, New York), (Figure 2). Subject set up followed the manufacturer's recommendations for each position, which often meant the use of a high-back booster seat or booster seat without the back was used for the smaller participants. Proper joint axes and angels were maintained for all subjects regardless of size, ensuring proper alignment with the dynamometer. Stiffness measurements were taken in 6 different motions:PF/DF, INV/EV in anatomical 0°, and INV/EV in 30° of PF. ROM on the Biodex for each set was determined by the comfort of each subject, as we wanted as close to full ROM as possible, without sacrificing the child's comfort. Each subject completed 1 set of 4 repetitions at 5°/sec., followed by 1 set of 5 repetitions at 30°/sec, and a third set at 60°/sec. in PF/DF and both INV/EV positions. The testing position order was randomized for each subject. Degrees and torque values were recorded throughout the entire ROM by the computer connected to the dynamometer. Subjects were instructed to push against the dynamometer as it moved through the ROM and were given verbal encouragement as well as visual feedback on each repetition as seen on the computer screen of the system.

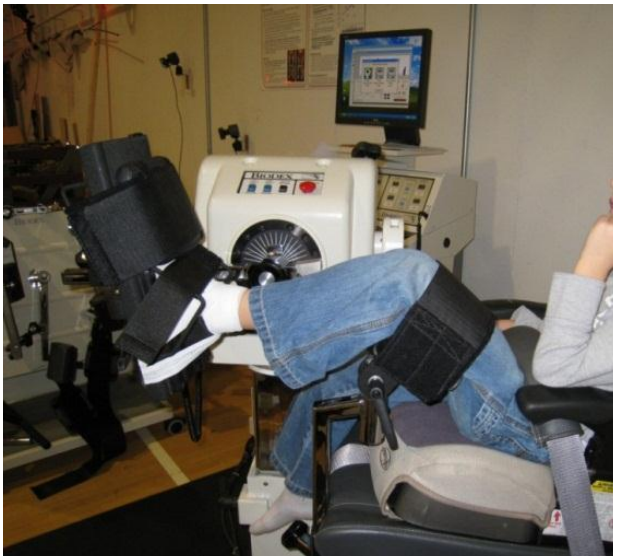

Figure 2. Child being measured on the Biodex System: Positioned for PF/DF measurement.

RESULTS

Anthropometry Measurements

Anthropometry measurements show an increase in all measures from group 1 to group 2, and to the adult values in presented in Crandall (1996) (Table 2).

Table 2: Anthropometry Data (Right / Left)

Measurement (cm)	Group 1	Group 2	Crandall et al.
Foot Length	17.5 / 17.5	20.5 / 20.3	24.4
Ball Length (5th Metatarsal)	12.2 / 12.2	14.4 / 14.3	16.3
Ball Length (1st Metatarsal)	13.5 / 13.4	15.6 / 15.4	19.6
Heel Width	3.8 / 3.8	4.2 / 4.2	7.0
Foot Breadth at MTP Joint	6.6 / 6.5	7.5 / 7.5	10.5
Medial Malleolus Height	6.0 / 6.0	6.5 / 6.4	8.3
Lateral Malleolus Height	4.5 / 4.4	5.1 / 5.1	6.9
Ankle Width at Malleoli	5.0 / 5.0	6.3 / 6.2	7.6
Plantar Arch Height	2.0 / 2.1	1.7 / 1.6	3.03
Ankle Length	8.6 / 8.6	9.9 / 9.8	10.8
Heel to Head of Lateral Malleolus	4.3 / 4.2	4.6 / 4.7	6.6
Tibial Height	30.1 / 31.0	37.9 / 37.6	47.0
Tibial Length	28.2 / 27.4	32.8 / 32.6	Not Reported
Seated Height	63.0	72.1	Not Reported
Knee Seated Height	36.5 / 36.6	44.4 / 44.2	Not Reported
Calf Circumference	23.0 / 23.0	25.8 / 25.6	Not Reported
Ankle Circumference	15.4 / 15.3	18.2 / 18.2	Not Reported

Goiniometry Measurements

Range of motion was averaged across groups for each motion measured. Independent measures t-tests (two-tailed) with a statistical significance of α=.05 was used to evaluate the ROM between group comparison. Range of motion data are presented in Table 3 below. Normal ROM values from the American Medical Association (AMA), the American Association of Orthopaedic Surgeons (AAOS), are presented alongside data from this study and data from Crandall, et al. (1996) in Table 4

Table 3: Statistically significant average range of motion values between Group 1 and Group 2

Motion (Degrees)	Group 1	Group 2	P-Value
Active DF Straight Leg - Left	13.23 (6.08)	8.29 (4.27)	0.022
Passive PF Straight Leg – Left	18.08 (6.70)	11.71 (4.62)	0.008
Passive PF Bent Leg – Left	79.15 (6.91)	72.81 (8.95)	0.041
Active DF Bent Leg – Right	21.23 (5.09)	14.69 (6.15)	0.004
Active DF Bent Leg – Left	21.54 (6.08)	16.25 (7.13)	0.041
Passive DF Bent Leg – Left	26.08 (4.92)	20.38 (4.70)	0.004
Passive DF Bent Leg – Left	28.23 (8.11)	21.06 (7.00)	0.019
Active Inversion – Left	38.92 (6.30)	34.35 (5.34)	0.047
Passive Eversion – Left	20.69 (6.01)	16.44 (4.38)	0.045

Table 4: Normal ROM values (degrees) compared to pediatric data and Crandall et al. (Range of motion values from the American Medical Association (AMA), the American Academy of Orthopaedic Surgeons, Group 1 and Group 2 data, and Adult data from Crandall et al.)

Motion (Degrees)	AMA	AAOS	Group 1	Group 2	Crandall et al.
Dorsiflexion	20	20	16.9	13.5	50
Plantar flexion	40	50	75.5	72.6	Not Measured
Inversion	30	35	45.8	42.3	50
Eversion	20	15	21.8	17.2	40
Rearfoot Inversion	----	5	13.1	13.9	Not Measured
Rearfoot Eversion	----	5	5.0	5.7	Not Measured

Dynamic Stiffness Measurements

Within subject repeatability is presented below with an example of a torque versus position plot from one subject (Figure 3).

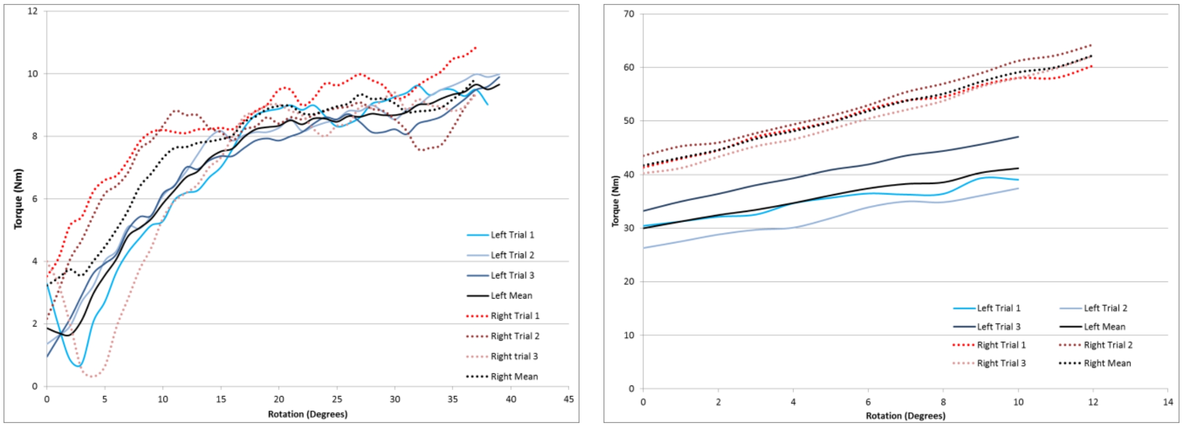

Figure 3. Plantar flexion testing at 30 °/sec (left) and dorsiflexion testing at 60 °/sec (right) for subject 204

At this time bilateral plantar flexion and dorsiflexion results have been analyzed for 5 subjects in Group 1 (4-7 years old) and 5 subjects in Group 2 (8-12 years old). Figure 4 shows plantar flexion at 30 °/sec from the 5 subjects analyzed in Group 1 on the left and 5 subjects from Group 2 at the same rate on the right. The figure also depicts the average curve for the 10 legs that are plotted in each group.

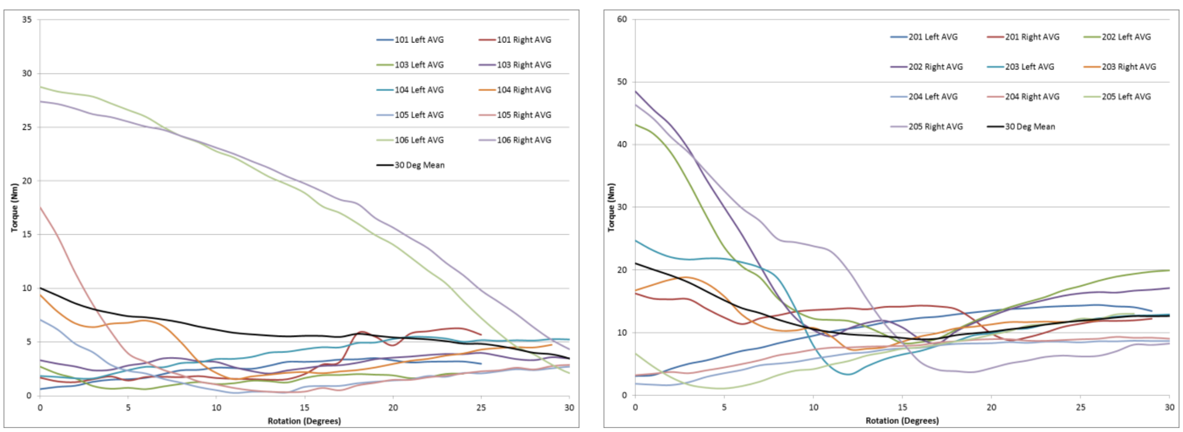

Figure 4. Plantar flexion testing at 30 deg/sec showing the output for Group 1 (left) and Group 2 (right)

The mean curves for both groups at all three plantar flexion testing rates (5, 30 and 60 °/sec) are revealed in Figure 5.

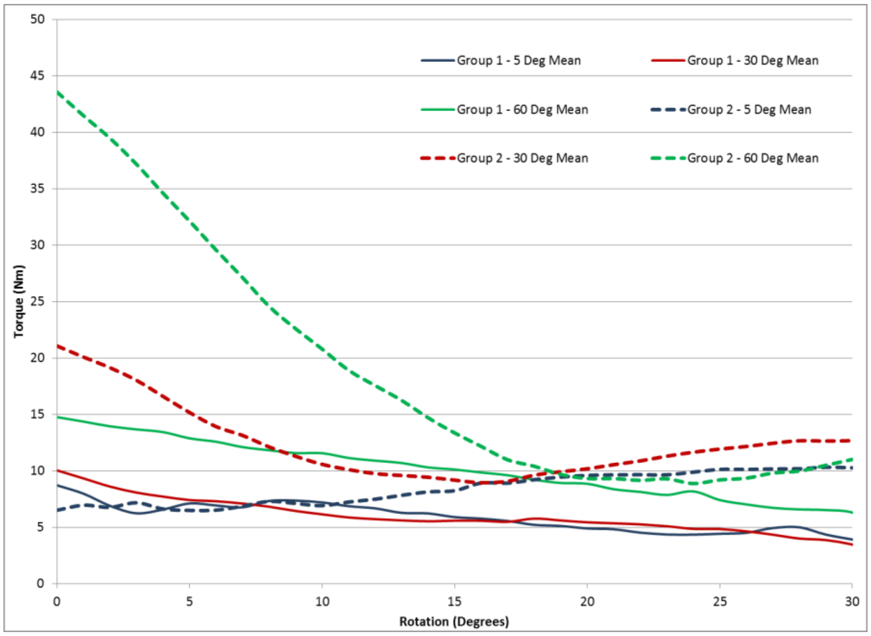

Figure 5. The mean plantar flexion results at 5 °/sec, 30 °/sec and 60 °/sec for both Group 1 and Group 2

The same analysis was completed for both groups undergoing dorsiflexion at the three test rates. The mean curves for both groups at all three dorsiflexion testing rates (5, 30 and 60 °/sec) are plotted in Figure 6.

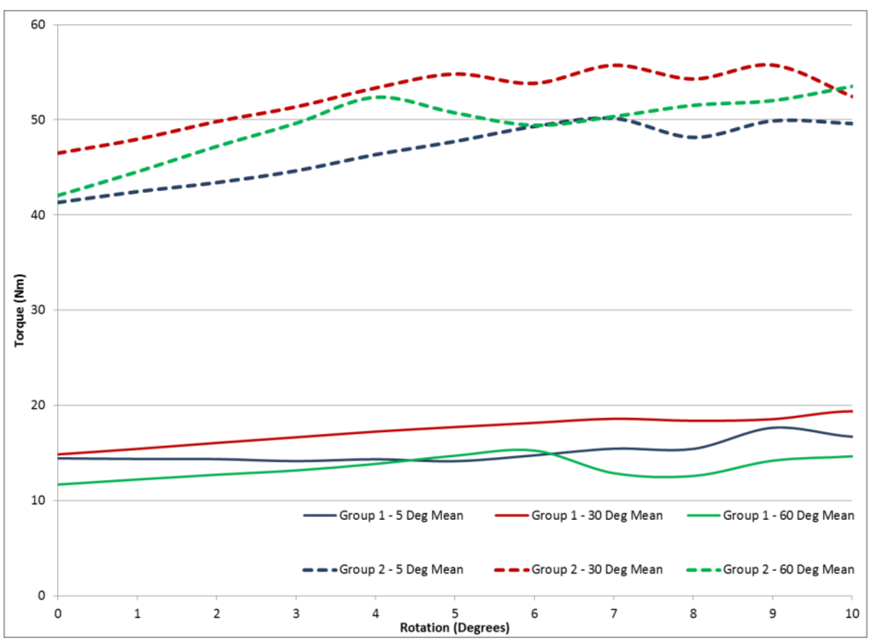

Figure 6. The mean dorsiflexion results at 5 °/sec, 30 °/sec and 60 °/sec for both Group 1 and Group 2

DISCUSSION

Currently the only way to gather meaningful information on injuries suffered in MVA's to the pediatric lower extremity is through database searches and retrospective reviews. Accident reconstructionists work on calculating crash and injury characteristics. This is currently the most accurate method of understanding the biomechanics leading to trauma in the pediatric victim, however it takes intricate databases and significant manpower to accurately reconstruct these scenarios. Most of the current information regarding injury biomechanics to the pediatric lower extremity is derived from case studies, which have limitations on generalizability. Another limitation of the current method of studying crash-injury characteristics is inaccurate documentation on restraint use and/or misuse (Jermakian, et al., 2007). Often restraint misuse is only documented when it is completely absent, versus involving an incorrect installation. Data on the effectiveness of child safety seat installation is imperative in understanding the mechanisms behind the injuries suffered in the crash.

Until the child can safely reach the floor, the foot and ankle remain vulnerable. In a study by Jermakian, et al. (2007), using database searches found that those in frontal crashes. Seventy-five children were seated in forward-facing child restraint systems (FFCRS) who had suffered an AIS 2+ injury, however only 20 children met the inclusion criteria, ranging in age from 8 months to 5 years old. The results from this study show that passenger cars had the majority of occupants with lower extremity injuries (17/20) and that the majority of the crashes involved frontal impacts (14/20). 85% of the lower extremity injuries involved the tibia and/or fibula.

The data from this study help to confirm the developmental differences in the pediatric population between our groups, who have an average age of 5.8 and 9.2 years, respectively. Differences in anthropometry were clearly expected, however of particular interest in the degree to which the differences are noted. Specifically in the heel width measurements of Group 1, measuring at 3.8cm and the adult value reported in Crandall et al. was 7.0cm. Foot breadth measurements of 4cm and 3cm smaller than the values reported in Crandall. Tibial growth was also of interest, both between groups as well as compared to the adult data. Growth was profoundly different between groups, averaging approximately 30cm in Group 1 to 38cm in Group 2 (please note the average age difference between groups is only 3.4 years). The adult data reports an average tibia length of 47cm, another 9 cm of growth.

Range of motion is known to change throughout life. Newborns have double the dorsiflexion motion, as compared to adults, but within the first five years this value should decrease (Nokin & White (2009). Plantar flexion in the newborn is less than adults, but quickly gains this motion within the first few weeks of life (Nokin & White (2009). Average normal ROM values as reported by the American Medical Association and American Academy of Orthopedics are represented in Table 3. The average ROM from this study is presented in full in Table 2. Some of the values of interest in our study include left straight leg passive dorsiflexion, left straight leg passive plantar flexion, bilateral bent knee dorsiflexion measurements (active and passive), left leg active inversion and passive eversion.

There is an overwhelming trend of the left ankle to show a higher likelihood of significant differences between the two groups. All but one of the subjects in the study were right foot dominant, as determined by the question, "What foot do you prefer to kick the ball with". It is unknown if foot dominance is predictive of a decreased ROM at this time. This also raises questions about strength and neuromuscular development that were not initial questions in this study, and may warrant further investigation, as ATD ankles do not account in any side to side variation. ROM comparison to Crandall et al. is interesting, as Crandall reports a much larger DF ROM in the bent knee position (50°), compared to Group 1 (25.4°/28.1°) and Group 2 (19.7°/19.2°). These differences bring into light the various measuring techniques and instruments that exist, which were not documented in the Crandall study, therefor comparison is invalid.

Joint stiffness is a complex interaction of the passive and active restraints about a joint. The tissues contributing to joint stiffness come from the muscles, tendons, ligaments, joint capsule, skin, fascia, and the cartilage that surround a given joint (Riemann et al., 2001). It is believed that increased stiffness is desirable, especially for protection against injurious forces (Riemann et al. 2001). Quantifying stiffness is a complex task and it is difficult to adequately represent all of the possible contributing factors. Assessing quasi-static and dynamic stiffness in children provide an even greater challenge. Variability in neuromuscular development, strength, and individual effort contribute to this greater challenge. It is well documented that mature gait patterns are not even reached, on average, until the age of seven years old. We must refrain from thinking of the growing and developing child as a small adult, as their complex and variable development provides one of the greatest challenges in pediatric research (Southerland, 1997).

The dynamic data suggest that there is some variability between subjects, as evident in figure 4. The most likely explanation for this is due to the vast difference in growth and neuromuscular development in children. Regardless of this variability, there was typically a consistent pattern through a given ROM for each subject. An interesting phenomenon exists in Figure 5, which plots the mean plantar flexion at all three speeds and compares the group means. The overall trend in Group 2 at 0° of PF is a greater torque production, which drastically decreases through the ROM as motion approaches 30° of PF. Group 1 only shows a minimal decline in torque from 0 to 30° of PF. Biomechanically the ankle is most stable at 0° and is at a more favorable length-tension relationship, and thus can generate more force in this position. As the ankle moves into PF, the ankle is placed in a less optimal length-tension relationship and loses bony stability provided by the ankle mortise, and is unable to generate the same amount of torque. The mean DF results, shown in figure 6 depicts the most drastic results, as Group 2 averages approximately 20-30 more Nm of torque throughout DF from 0-10°. It is also interesting to note that both groups generated the most torque at 30 °/sec. As stated previously, DF is a stable position, but it is also the position that is most injurious in MVA's if there is an axial load transmitted up through the ankle, as is demonstrated in frontal collisions.

CONCLUSIONS

The results of this investigation help to show evidence that differences truly exist in between the 6 and 10 year old child group and help to highlight the importance that the 6 and 10 year old ATD need to accurately reflect these differences in anthropometry, ROM, and stiffness. Not only will a properly instrumented pediatric ATD allow for advances in automotive safety and manufacturing of safer child restraint systems, it will allow us to directly measure optimal and suboptimal positioning of the child with a more accurate picture of the forces experienced by the vulnerable lower extremity. Understanding the entire scope of the accident is critical in lessening the severity and frequency of such injuries. The information gained by this study may also give clinicians a greater understanding of the pediatric ankle tolerance and response, which may assist in further understanding ankle injuries suffered in sport and other accidents.

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APPENDIX A: Anthromopetry Measurments

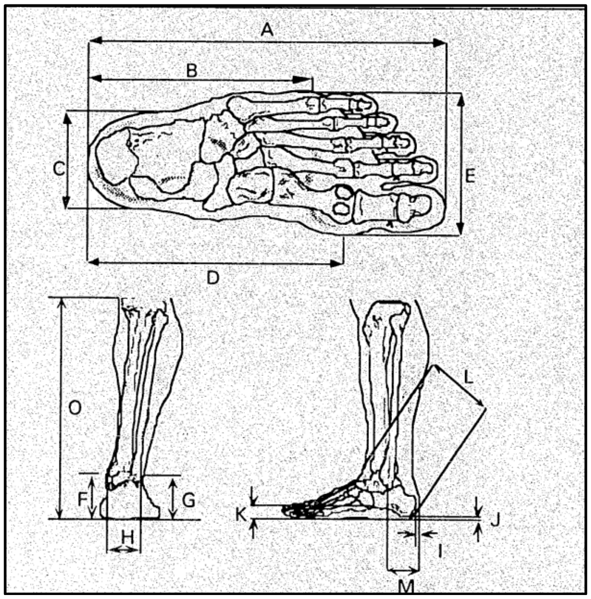

Figure 7. Anthropometry Diagram (Crandall et al, 1996)

A - Foot Length (FTL
B - Ball Length – heel to 5th met (BL)
C - Heel Width (HW)
D - Ball Length – heel to 1st met (BL)
E - Foot Breadth at MP Joints (FTBMTP)
F - Medial Malleolus Height (MMHT)
G - Lateral Malleolus Height (LMHT)
H - Ankle Width at Malleoli (ANKW)
K - Plantar Arch Height from floor (FTAHT)
L - Ankle Length - heel to front of ankle (ANKL)
M - Heel to Head of Lateral Malleolus (HHLM)
O - Tibial Height - heel to tibial plateau): (TIBHT)

NHTSA TEST REFERENCE GUIDES VOLUME II: VERSION 5 BIOMECHANICS TESTS

TIBLHT — Tibial Height

TIBLHT is the knee height of the test occupant, measured from the most distal portion of the heel to the proximal medial margin of the tibia. The measurement may be obtained by measuring either the distance to both the right and left heels and averaging the two values; or by measuring the distance from the vertex of the head to the proximal medial margin of the tibia and subtracting that value from STATUR.

ANKLHT — Ankle Height

ANKLHT is the height of the test occupant's ankle as measured, with sliding calipers, from the most distal portion of the heel to the level of the minimum circumference of the ankle (at the level proximal to the malleoli of the tibia and fibula perpendicular to the long axis of the lower leg).

FOOTBD — Foot Breadth

FOOTBD is the breadth of the test occupant's foot, measured with sliding calipers, at the level of the metatarsal-phalangeal joints along an axis perpendicular to the long axis of the foot. Measure the breadth of both feet and take the average to obtain FOOTBD.

FOOTLN — Foot Length

FOOTLN is the length of the test occupant's foot, measured from the dorsal surface of the heel to the tip of the big toe by the use of a beam caliper. Measure the length of both feet and take the average to obtain FOOTLN.

SEATHT — Seated Height
SEATHT is the test occupant's seated height, measured as the vertical distance from the sitting surface to the top of the head. The measurement is taken with the test occupant sitting erect, looking straight ahead. This measurement must be made in all cases where the test occupant is seated during testing.

KNEEHT — Knee Height, Seated
KNEEHT is the knee height of the test occupant, taken as an average of the vertical distance from the floor to the uppermost point on the knee of both legs. The measurement is taken with the test occupant sitting erect, knees and ankles at right angles. This measurement must be made in all cases where the test occupant is seated during testing.

APPENDIX B: Range of Motion Data

Average Range of Motion Data			
Motion	Group 1	Group 2	P-value
Active PF Straight Leg – Right	68.92 (8.09)	69.00 (9.66)	P-Value = 0.981
Active PF Straight Leg – Left	71.85 (5.18)	72.10 (10.10)	P-Value = 0.941
Passive PF Straight Leg – Right	74.23 (6.37)	72.65 (8.75)	P-Value = 0.571
Passive PF Straight Leg – Left	77.23 (5.61)	72.10 (10.10)	P-Value = 0.086
Active DF Straight Leg – Right	12.00 (7.98)	9.24 (5.77)	P-Value = 0.303
Active DF Straight Leg – Left	13.23 (6.08)	8.29 (4.27)	P-Value = 0.022
Passive DF Straight Leg – Right	16.92 (8.36)	13.53 (5.26)	P-Value = 0.215
Passive PF Straight Leg – Left	18.08 (6.70)	11.71 (4.62)	P-Value = 0.008
Active PF Bent Leg – Right	71.46 (6.79)	69.75 (8.36)	P-Value = 0.548
Active PF Bent Leg – Left	75.15 (7.32)	70.10 (10.00)	P-Value = 0.127
Passive PF Bent Leg – Right	76.54 (5.36)	72.50 (8.07)	P-Value = 0.119
Passive PF Bent Leg – Left	79.15 (6.91)	72.81 (8.95)	P-Value = 0.041
Active DF Bent Leg – Right	21.23 (5.09)	14.69 (6.15)	P-Value = 0.004
Active DF Bent Leg – Left	21.54 (6.08)	16.25 (7.13)	P-Value = 0.041
Passive DF Bent Leg – Left	26.08 (4.92)	20.38 (4.70)	P-Value = 0.004
Passive DF Bent Leg – Left	28.23 (8.11)	21.06 (7.00)	P-Value = 0.019
Active Inversion – Right	38.31 (9.43)	35.82 (5.29)	P-Value = 0.406
Active Inversion – Left	38.92 (6.30)	34.35 (5.34)	P-Value = 0.047
Passive Inversion – Right	45.8 (12.3)	42.35 (5.94)	P-Value = 0.359
Passive Inversion – Left	44.54 (8.90)	39.71 (6.34)	P-Value = 0.112
Active Eversion – Right	16.08 (7.38)	12.71 (3.44)	P-Value = 0.148
Active Eversion – Left	16.38 (5.81)	12.53 (4.26)	P-Value = 0.057
Passive Eversion – Right	20.46 (5.85)	17.24 (3.88)	P-Value = 0.102
Passive Eversion – Left	20.69 (6.01)	16.44 (4.38)	P-Value = 0.045
Rearfoot Inversion – Right	14.54 (8.38)	13.88 (5.97)	P-Value = 0.813
Rearfoot Inversion – Left	16.92 (8.51)	13.13 (3.86)	P-Value = 0.157
Rearfoot Eversion – Right	5.77 (4.40)	5.69 (3.07)	P-Value = 0.955
Rearfoot Evesion – Left	6.46 (2.79)	5.88 (2.13)	P-Value = 0.538