Epidemiology of injury rates among high school athletes

Amanda Carroll
The University of Toledo

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A Thesis

Entitled

Epidemiology of Injury Rates among High School Athletes

By

Amanda Carroll, ATC, LAT

Submitted as partial fulfillment of the requirements for
The Master of Science degree in
Exercise Science

Advisor: Dr. Phillip Gribble

Committee Member: Dr. James Rankin

Committee Member: Dr. Leonard Greninger

College of Health and Human Services

College of Graduate Studies

The University of Toledo

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Objective: To examine how sex, sport, bracing, taping, and session (competition/practice) influence the injury rates of the ankle among high school athletes in the Toledo, OH area. **Design and Setting:** The Athletic Trainers at each high school was contacted every week and asked to report the data from the previous week. The information collected was transferred to a data collection form by the principal investigator and then entered into Excel spreadsheet for processing. The number of the total injuries for each injury category listed on the questionnaire served as the dependant variables, and the independent variables were sport, sex, protection, and session. For each independent variable, we used pure descriptives, and reported the number of injuries for each dependant
variable/injury category from the survey. **Data Source:** Athletes ranging from 14-18 years old participating in the sports of volleyball, football, men’s and women’s soccer, and men’s and women’s basketball. **Measurements:** The following injuries were monitored: Grade I lateral and medial ankle sprain, Grade II lateral and medial ankle sprain, Grade III lateral and medial ankle sprain, dislocation, Achilles tendon Grade I, Grade II, and Grade III or rupture, peroneal tendon injuries Grade I, Grade II, and Grade II, and fracture, and graded by a certified Athletic Trainer. **Results:** Football and basketball had higher incidences of lateral ankle sprains grade I than volleyball and soccer, and basketball had more injuries than football. When the total number of ankle/foot injuries was considered for each sport, football had the most injuries. Basketball was next, and then there was a large drop off in the number of injuries in volleyball and soccer. Overall, males had four times more injuries than females when all ankle/foot injuries were combined. There were higher numbers of ankle/foot injuries in practice than in competition when all injuries were combined. There was a higher amount of injuries to the foot/ankle in athletes with no protection. Bracing had the next highest amount of injuries, and tape was only slightly lower than bracing. **Conclusions:** The evidence suggests that football and basketball have higher amounts of injuries, males are injured more than females, competition injuries are more severe than practice injuries, and taping and bracing were better than no protection with taping being slightly better than bracing.
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Chapter 1

Introduction

There is an estimated 7 million high school athletes in the United States between the ages of 14 to 18, with 4.1 million males and 2.0 million females participating in organized athletic activity. Over the past 10 years there has been a 21% increase in athletic participation in this age group [1]. This high increase in sport participation has led researchers to identify risk factors for specific injuries commonly observed in the high school athlete. Annually, there are an estimated 4.5 million injuries attributed to sports and recreation for young adults in the United States [2]. The ankle is the most common site of injury for adolescents in high school sports, with approximately 10% to 28% of the injuries occurring to the ankle [3]. With ankle sprains accounting for close to 85% of all foot and ankle injuries, it is considered the most frequently experienced athletic participation injury[4].

Injury rates have been reported in many different studies for prevention purposes [5-14] ; however there has not been a study that has included a comparison of sex, sport differences, session (competition/practice), bracing, and taping of the ankle specifically to examine contributions to the high rate of ankle sprain injury. These factors, individually or in combination, may provide important insight on the development of ankle injury in the adolescent athlete. The passage of Title IX has increased the number of females in sports
dramatically [15]. Subsequently, many authors have detailed the injury differences between males and females [16, 17]; however, other than the knee [18], no significant differences in injury rates to other parts of the body have been reported between males and females. There have been reported differences in injuries between sports, indirectly demonstrating a difference in injury rates between sexes. Ankle injuries have been found to be much more prevalent in high school football players (males) than in high school volleyball players (females) [4, 19]. Finally, numerous studies have reported that competition injuries are more frequent and severe than practice injuries [14, 20-22].

Prophylactic ankle taping and bracing is used commonly in clinical practice for the prevention of ankle injury. However, there is some inconsistency in the reporting of effectiveness of these techniques. Several studies have shown that taping and bracing provide minimal support during exercise [23-27]; while others have reported that taping and bracing are effective at reducing ankle sprain injury rate. [4, 28]. Finally, others recommend that the use of semirigid stirrup-configured braces when possible [29-33]. In addition to examining the ankle injury rates of males and females across multiple sports, important information can be gained about effective intervention strategies by comparing the injury rates between those that did and did not have prophylactic taping or bracing applied to their ankles.

**Statement of the Problem**

While large epidemiologic data regarding ankle injuries have been obtained for high school sports, few studies have included comparisons between sex, sport, session (competition/practice), and bracing/taping of the ankle. Prior to this study, there was a considerable amount of variability in the methods and type of data collected in similar studies.
The variability in this data has made it challenging for Athletic Trainers to find and use the information for preventing injuries. All of the factors were examined together, and the hope was that a better prevention protocol can be established. Additionally this epidemiological data has not been collected in the Toledo, OH Lucas County area previously. There was a need to examine across all of these fields, individually and in combination, to determine how these factors correlated to injury rates to establish risk factors and subsequently develop effective prevention techniques.

**Statement of the Purpose**

The purpose of this study was to examine how sex, sport, bracing, taping, and session (competition/practice) influence the injury rates of the ankle among high school athletes in the Toledo, OH area. The intention was that this study would help clinicians and researchers in the Toledo area and across the country manage ankle injuries more effectively.

**Significance of the Study**

The most common site of an athletic injury is the ankle. To our knowledge, sex, taping/bracing, sport type, or sessions (competition/practice) have not all been included in a single epidemiological study. The results of this study may help contribute to the prevention and reduction of ankle sprains among high school athletes.
Research Hypotheses

H₁: Females will have a higher incidence of injuries than males in soccer and basketball.

H₂: There will be less ankle injuries for athletes that were in a brace compared to taping and nothing at all.

H₃: Football will have the highest rate of ankle injuries compared to the other sports included in this study.

H₄: Competition injuries will be more severe than practice injuries.
Anatomy

The two main ligaments to support the ankle are the medial and lateral collateral ligaments. The lateral collateral ligament has three bands composed of the anterior talofibular ligament, the posterior talofibular ligaments, and the calcaneofibular ligament. The anterior talofibular ligament attaches from the neck of the talus to the tip of the fibula; the posterior talofibular ligament runs from the body of the talus to the tip of the fibula; and the calcaneofibular ligament runs from the calcaneus to the tip of the fibula. The medial collateral ligaments are also called the deltoid ligament. Each of the lateral ligaments has a primary function. The anterior talofibular ligament’s function is to restrain anterior displacement of the talus; the posterior talofibular ligament is to restrain posterior displacement of the talus; and the calcaneofibular ligament is to restrain inversion of the calcaneus [34].

The anterior talofibular ligament is the most commonly damaged due to it having the weakest tensile strength of all the lateral collateral ligaments [35]. The most common mechanism for an inversion ankle sprain is inversion, plantar flexion, and internal rotation. An
eversion ankle sprain is much less common due to the bony and ligamentous anatomy. The fibular malleolus extends further inferiorly than the tibial malleolus. Also the deltoid ligament is very thick which adds to the prevention of excessive eversion.

**Injury Definitions**

There are several commonly associated musculoskeletal injuries and pathologies experienced in the ankle/foot complex. For this document, the definitions provided by Arnheim [34] will be used. Below is a list of these injuries followed by a brief description.

**Grade I inversion ankle sprain**- Mild pain and disability on the anterior talofibular ligament. Weight bearing is minimally impaired. Point tenderness and swelling over the ligament with no joint laxity.

**Grade II inversion ankle sprain**- May be a complete tear of the anterior talofibular ligament and a stretch and tear of the calcaneofibular ligament. A pop or snap was felt on the lateral side of the ankle. Weight bearing is difficult, and there is moderate pain and disability. Tenderness and edema is present, and ecchymosis may occur. Possible positive talar tilt and positive anterior drawer sign between 4 and 14mm.

**Grade III inversion ankle sprain**- Involves varying degrees of damage to the anterior talofibular ligament, calcaneofibular ligament, posterior talofibular ligament, and the joint capsule. There is severe pain around the lateral malleolus, with weight bearing being not possible due to the large amounts of swelling. Hemarthrosis, discoloration a positive talar tilt, and a positive anterior drawer test are also present.
Grade I eversion ankle sprain - Mild pain and disability. Point tenderness and swelling over the deltoid ligament with no joint laxity. Weight bearing is minimally impaired.

Grade II eversion ankle sprain - A pop or snap was felt on the medial side of the ankle. Weight bearing is more difficult, and there is moderate pain and disability. There is tenderness and edema with blood in the joint and possible ecchymosis.

Grade III eversion ankle sprain - There is severe pain around the medial malleolus, with weight bearing being not possible due to the large amounts of swelling. Hemarthrosis, discoloration a positive talar tilt, and a positive anterior drawer test are also present. Both abduction and adduction cause pain.

Ankle fracture/dislocation - There is extreme swelling and pain possible with some or no deformity. Ecchymosis is possible. Many different mechanisms possible with varying bones likely damaged.

Grade I Achilles tendon strain - A slight pull of the tendon with microscopic tendon tearing. No loss of strength or change in length of the tendon with possible pain, tenderness, swelling, warmth, and redness.

Grade II Achilles tendon strain - Tearing of the tendon fibers within the tendon or at the tendon/bone junction. There is an increase in length with a decrease in strength with increased pain, tenderness, swelling, warmth, redness, pain with ankle motion, and crepitation.

Grade III Achilles tendon strain (rupture) - Pain is immediate but rapidly subsides with point tenderness, swelling and discoloration common. Unable to do toe raises. Possible indentation at the tendon site and a positive Thompson test.
**Grade I Peroneal tendon strain** - Flattening of the peroneal tendon with no tear. Behind the lateral malleolus there is pain, swelling and warmth.

**Grade II Peroneal tendon strain** - Partial thickness split of the tendon, with weakness or instability of the joint. Subluxation possible of the retinaculum. Recurrent pain, snapping, ecchymosis, edema, tenderness, and crepitus over the peroneal tendon.

**Grade III Peroneal tendon strain** - Full-thickness split with dislocation common. Recurrent pain, snapping, ecchymosis, edema, tenderness, and crepitus over the peroneal tendon.

**Risk Factors**

According to Gross and Liu[36], there are two main risk factors for ankle sprains. The first is a previous ankle injury, and the second is the sport demands on the ankle[36]. Baumhauer et al. [37] found that as far as intrinsic risk factors were concerned, generalized joint laxity for ankle alignment and ankle ligament stability were not a risk factor of significance for an ankle injury [37]. Willems et al. [38] found that there was no significant relationship between any anthropometrical measures and ankle sprains [38].

A study by Emery [19] looked at the risk factors for adolescents in athletic settings. The intrinsic factors which she identified were sex, age, skill level, sport being played, recurrent injury, and competition. Males have been found to be at a greater risk for injury due to aggression, larger body mass, and greater experience. These factors could lead to greater forces being applied in running, jumping, pivoting and contact with another player compared to females. Females were found to have a greater injury risk in soccer and basketball possibly due to inexperience, or physiologic differences. Age is a factor for a few reasons. With an increase
in age there is a higher level of competition, contact, and size of the athlete. There is also an increase in time playing the sports with an increase in age. With an increase in skill level the incidence of injuries have found to decrease in most sports [19]. Contact sports have a much higher risk of injury than non-contact sports due to the collisions between athletes. Previous injury is associated with a clear increase in risk of injury due to persistent symptoms or physiological deficiencies. There could be an increase in ligament laxity and decreases in muscle strength, endurance, or proprioception. Also, competition has been found to have an increased chance and severity of the injury [14, 20-22]. Not only is the athlete working harder, but the competitors are more likely to increase their intensity level as well.

Extrinsic risk factors include: playing surface, coaching, obesity, strength, fitness level, flexibility, and protective equipment [19, 39]. Each of the extrinsic risk factors can be modified. First, the playing surface can contribute to an increase in injury rates, but there is very limited information on playing surface with regards to risk of injury among high school athletes. Second, coaching has been thought to affect injury risks. A study done by Shultz et al. [40] reported that coaches with a college degree and more years of coaching experience had a reduced risk of injury among competitive cheerleaders[40]. Next, obesity may be considered as a risk factor as studies that have found that athletes with a higher BMI were 19 times more likely to sustain a noncontact ankle sprain than normal weight athletes [26, 41]. Finally, strength as an extrinsic risk factor has been examined by Beynnon et al. [42]. In their earlier studies [37] an increase in strength was shown to decrease ankle sprains; however in a more recent study done by Beynnon, strength was not shown to influence ankle injury rates [42].
**Ankle Prevalence**

Injury to the ankle complex can be argued to be the most prevalent among athletic participation. Hansen et al reported that 67.3% of football players had sprained their ankle during a single season; while Smith and Reischl [43] found that 70% of basketball players had a history of ankle sprain and 80% had sustained multiple ankle sprains. Willems et al. [38] found that 18% of their 241 subjects had one or more inversion sprains. Miller et al. [44] found that around 10% to 30% of all musculoskeletal injuries are located at the ankle [44]. Mueller et al. [45] reported that knees were more commonly injured with ankles second; but Turbeville et al. [46] found that prevalence of injuries to the ankle were 27% and the knee was 20% [46]. Emery et al. [47] found that ankle injuries were the most common with 28.2% of all injuries in high school soccer players. Lower extremity injuries were 78.2% of all the injuries as well [47].

**Injury Type**

Sprains are the most frequently reported injury of the ankle. Garrick and Requa [4] found that 90-95% of ankle sprains are inversion ankle sprains causing partial or complete rupture of the anterior talofibular ligament and occasionally the calcaneal-fibular ligament [4]. Several other studies have found that ankle sprains are the most common location, with sprains/strains as the most common injury [17, 41]. Leininger et al. [48] found that lower extremity injuries were the most common in soccer players with 47.3% of the total; and the most common type of injury was the sprain/strain with 35.9%, and the fracture second with 23.2% [48].
Nelson et al. [14] reported that the most frequently diagnosed injury to the ankle was a ligament sprain with incomplete tears (83.4%), followed by fractures (5.2%), ligament sprains with a complete tear (4.0%), and contusions (2.0%). This study found that 81.8% of all ankle injuries were new, and 9.4% of all injuries were recurrent injuries [14]. Rechel et al. [49] reported that the most common injury occurred was sprains/strains (52.1%), then contusions (12.3%), and then fractures (9.8%). Sprains and strains were the most common in volleyball (77.3%) and women’s basketball (62.5%). Sprains/Strains were more common in practice than competition, specifically in men’s and women’s soccer [49].

Finally, and perhaps the most telling, in a 16 year long study of NCAA athletes’ ankle sprains were the most common injury in all sports in games and practices [5-10]. However, most of these studies have examined injury rates among collegiate athletes. What is lacking is injury information among the high school athletic population.

**Prophylactic Ankle Support**

Ankle taping and braces are often employed prophylactically to prevent first time and recurrent ankle injury. These interventions are proposed to reduce inversion by increasing the stiffness of the ankle joint, and by limiting motion, thus preventing a further inversion motion by contributing to static stability of the joint complex. Ankle braces and taping are used to control swelling, range of motion in the acute stage, and to provide stability to the ligaments during activity. The support system that provides the most effective stabilization is continually debated.
**Bracing**

Many studies have examined the effectiveness of supporting the ankle. Bracing is usually found to be beneficial at reducing ankle sprains; however, the exact mechanism of what a brace does is still not completely understood. There is some inconsistency as to whether an ankle brace can be harmful to performance. Some studies have reported that bracing and taping impair the activities of jumping and running [24]; while another study reported improved performance when using bracing [29]; and still other studies have found no differences whether braced or not [50]. According to Canavan [51], healthy ankles do not need bracing or taping, but for athletes with a history of ankle injuries taping or bracing is recommended. The compression of taping or bracing can help reduce edema for an acute ankle sprain. Taping and bracing is proven to have greater proprioceptive benefits that outweigh the restriction of the total movements [31]. Cordova et al. [52] looked at a lace-up brace, semirigid style brace, and tape on their effects of sprint speed, agility, and vertical jump performance. They found that the greatest effect of an ankle support device on performance was the negative effect the lace-up brace had on sprint speed. None of the other comparisons were found to be significant. Each had a slightly negative effect, but not enough to hinder their performance [52].

The primary purpose of an ankle brace is to restrict frontal plane motion. In a meta-analysis by Cordova et al [52], semirigid braces had a greater inversion restriction than taping and lace-up braces before and after sports. The lace-up brace also had more restriction than the taping did, but the taping had more ability at limiting ankle dorsiflexion than the lace-up [52].

Sitler et al [32] examined the use of an Aircast stirrup brace compared to a control group for 1601 athletes. They reported the brace was able to significantly reduce the frequency of
ankle injury, and the athletes that didn’t use the brace had a three times more likelihood of injuring the ankle [32]. Similarly, Garrick reported a reduced number of ankle sprains in male basketball players when they were taped and had high-top shoes on [4]. In a study by Rovere [30] examining 297 football players, a non-rigid lace-up brace reduced the chance of ankle sprain in half compared to a taping method. To the authors attributed the effect from bracing to the fact that the athlete was likely readjusting to the tension of the brace throughout an exercise session [30].

Tropp et al [33] studied the effect of bracing versus a proprioception program for 450 soccer players and a control group for 6 months. For the athletes that had no previous injury 3% were injured in the bracing group, 5% in the proprioception training group, and 11% in the control group. They also compared those with previous injury and found that the bracing group had a 2% injury rate, a 5% injury rate for the proprioception training group, and 25% injury rate for the control group. This study concluded that bracing and proprioception training significantly lowered the incidence of injury for ankle sprains, especially in those with previous injury [33].

Surve [53] also examined the effectiveness of ankle braces at reducing injury, this time among 600 soccer players with a previous history of ankle sprains compared to those who were injury free. Consistent with Tropp [33], ankle braces are effective at reducing the chance of ankle sprains of those with a history of injury. However, Surve [53] reported that the braces are not as effective at preventing the first time sprain. Those without a history had 32 ankle sprains in the braced group and 33 in the control group. With the athletes with a history of sprains, only 5 were injured in the braced group while 31 that were unbraced with a history of ankle injury suffered another injury [53].
Sharpe et al [54] studied 38 collegiate soccer players over a 5-year period. Of the 76 ankles, 56 had a previous history of ankle sprains. Each athlete wore a canvas brace on 19 ankles and all of them had no recurrence of the injury. Those that were unbraced had a 35% rate of recurrence to the sprain. There was a re-injury rate of 25% (3 of 12) among subjects with previously sprained ankles when taped, and a 25% re-injury rate (2 of 8) in taped and braced athletes [54].

Conversely two studies noted that athletes wearing an ankle brace and tape had a higher chance of injury than those who did not wear a brace [26, 27]. Additionally, both studies reported that athletes wearing a brace with no history of ankle injury had a larger possibility of sustaining an ankle injury.

Nelson et al. [14] found that of all the ankle injuries they studied, only 7.8% were wearing an ankle brace. Football athletes were wearing a brace when hurt 10.8% of the time, female soccer players suffered an injury with a brace on 2.5% of the time, while male soccer players suffered no ankle injuries among the players that were wearing an ankle [14].

Ubell et al [55] using 14 healthy male ankles, compared the effects that three different kinds of ankle braces had on the reduction of forced inversion. All three braces decreased the forced inversion upon landing from a jump by nearly threefold. However, the two semi-rigid braces (Bledsoe and Aircast) prevented inversion better than the lace-up brace (Swede-O) [55].

**Taping**

According to Sawkins et al [56], ankle taping techniques are beneficial by providing mechanical support and enhancing proprioception. The tape provides limits to extreme joint positioning of inversion, eversion, and plantarflexion [28]. However, it has been proven that
after 10 minutes of exercise, the restrictive capabilities are significantly reduced [52, 57, 58].

The proprioceptive factors thought to be improved by tape are increased excitability of cutaneous receptors [59] and muscle afferents [25]. Proprioception has found to improve the joint position sense of inversion and plantarflexion in first time ankle sprains [28], but has been not shown to improve in recurrent ankle sprains and those with no previous injury in plantarflexion-dorsiflexion [25] or inversion-eversion planes [23]. The other way taping is of assistance is that the athlete may compete with more confidence if they believe the taping is helpful [56].

Ankle taping is proposed to create cutaneous sensor cues of orientation from the plantar surface to anticipate the foot contact. According to Robbins et al [59], ankle taping positions the plantar surface to support the inversion forces, or to obtain the muscle support to sustain the forces. This reduces ligament loading, which leads to the hypothesis that ankle sprains are caused by improper foot positioning with inadequate anticipatory movements in sports with insufficient time to respond to the load. Robbins et al did report that taping improved foot position awareness and negates the underestimation of foot position angle caused by athletic footwear [59].

Garrick and Requa [4] examined 2563 basketball players with previous ankle sprains over two successive seasons. Those who wore a zinc oxide stirrup with horseshoe and figure of eight with a hightop shoe had an incidence of 6.5/1000 injuries per game. The players that were untaped with the same shoe had an incidence of 30.4/1000 games. Taping with a low support shoe had a 17.6/1000 incidence of injury. This research showed that taping has an influence in preventing ankle sprains, though the role of shoe type in helping stability is undecided [4]. Heit et al [28] found that taping was more effective at improving joint position sense for inversion
and plantar flexion. Bracing was shown to only improve proprioception during plantar flexion [28].

**Sex Differences**

The influence of sex on injury risk has been studied at length, with conflicting results and limited investigation at the ankle. A large reason for this interest is because of the dramatic increase in the number of females participating in sports over the last several years [15]. Hosea et al [16] looked at men’s and women’s basketball at 95 different schools with varying levels over a 2-year period. Grade I ankle sprains comprised 72% of all the injuries for males and females. Females had a Grade I ankle sprain injury rate 24% higher than males. However, there was no difference in risk for Grade II or III sprains, syndesmosis sprains, or ankle fractures between males and females [16].

Fernandez [60] found that soccer was the sport with the highest injury rate for females; however males had a higher injury rate than females. Females did have a 3.5 times higher outcome of surgeries than males [60]. In contrast, Leninger [48] reported females having 25% more injuries, with boys having 85% more surgeries than females in children and young adults [48].

Powell and Barber-Foss [17] also examined sex-related injury patterns in high school athletes. They observed the sex differences between both sexes in basketball, soccer, softball, and baseball. In basketball the ankle/foot was injured the most in the men’s and women’s team. For the males, the ankle/foot was 39.3% and females 36.6% of the total number of injuries. Males were found to have more traumatic injuries such as fractures; while females had
a higher rate of strains than the men’s teams. Females were also found to have a greater severity of the injury than males during basketball. Females had a greater percentage of new and recurrent injuries than males did. The females also had more game related injuries than males. There were no differences in the sexes for the type of activity session (competition or practice) for basketball. Soccer was also found to have the ankle/foot as the most common site of injury with males comprising 33.3% and females comprising 33.5% of all of the injuries. Ankle sprains were once again the most common injury and males had more fractures than females. Females did have a higher incidence of recurrence of injuries than males in soccer. There was no difference between practice and competition between males and females playing soccer. Overall this study found that females had a higher injury rate of the whole body than males for soccer, but not for basketball [17].

Emery et al. [11] also reported that there was no difference in males and females in overall injury rates for soccer players in Canada [11]. Specific to ankle sprains, McGuine and McHugh did not find differences between the sexes [39, 61] Leninger et al. [48] found that in soccer, males had more injuries than females with 58.6% of all the injuries. Females were more likely to have ankle injuries, and also more sprains/strains than males [48].

Nelson et al. [14] reported that overall females and males had similar injury rates, but in sports played by both sexes (soccer and basketball) males had a higher injury rate during practices, and girls had more injuries during competition. The ankle had a higher proportion of all injuries for a female (32.5%) than a male (18.4%) [14]. In slight contrast, Beynnon et al [42] focused on first time ankle sprains and found that women’s basketball athletes had a higher injury rate than men’s basketball players. The men were also found to have no association between sport type and first time ankle sprains [42].
Competition vs. Practice

The level of intensity during competition sessions is inherently increased compared to practice sessions. Many studies have found that there is an increased risk of injury in competitions compared to practices. The dramatic increase of injury during competition was reported in football [46, 62], soccer [47], and basketball [13]. Junge et al [20] compared practice to competition for soccer players. Two-thirds of all of the injuries occurred during games, and only 20% of the injuries occurred during practice [20]. In around 100 high schools in Texas, the practice injury rate was 5.3 injuries for 1000 athletic exposures and the game injury rate was 26.4 per 1000 athletic exposures [17].

Soderman et al [22] found a 6 times increase in injuries during games versus practice, while Emery et al [47] found a 6 times greater injury rate. Peterson [21] found the injury for 16-18 year olds to be doubled during competition. Nelson [14] et al reported that competitions had a higher injury rate than practices in football men’s and women’s soccer, and men’s and women’s basketball. However, volleyball did not have a higher injury rate during competition [14]. Rechel et al [49] reported that lower extremity injuries occurred in similar proportions in practice and competition injuries. Soccer was the only sport to find a large proportional difference in practice compare to competition [49].

The NCAA conducted a 16 year long injury surveillance of collegiate athletes and found that in men’s basketball ankle sprains accounted for 26.2% of all injuries during competition, and 26.8% of all injuries during practices. However, the incidence of competition injuries was considerably higher in the NCAA (9.9 injuries per 1000 athletic exposures) compared to the Canadian collegiate league (6.0 injuries per 1000 athletic exposures), while the NBA injury rates are nearly twice as high (19.3-21.4 per 1000 athletic exposures) [9]. Women’s basketball had a 2
times higher injury rate in games compared to practices (7.68 vs. 3.99 injuries per 1000 athletic exposures) [6]. Football had a 9 times higher injury rate in games than in practices (35.9 vs. 3.8 injuries per 1000 athletic exposures) [8]. Men’s soccer had a 4 times higher injury rate in games than practices (18.75 vs. 4.34 injuries per 1000 athletic exposures) [5]. Women’s soccer had a 3 time higher injury rate in games compared to practices (16.4 to 5.2 injuries per 1000 athletic exposures) [10]. Finally, volleyball saw only a slightly higher incidence of injury in games compared to practices (4.58 versus 4.10 injuries per 1000 athletic exposures) [7].

**Comparison between Sports**

Garrick and Requa [4] examined the sports with the highest ankle injuries. They found that the sport with the highest proportion of ankle sprain was in volleyball with 82% and basketball with 79%. Foot injuries were much less common. Volleyball had the highest proportion of foot overuse injuries [4]. McKay, examining injuries in basketball, reports the ankle is the site with the most injuries for basketball with inversion ankle sprains being the highest injury incidence rate, with an 3.85/100 ankle sprains per incidence on average [4]. Knowles et al [63] examined whether prior injuries were more affected in practice or competition, reporting that previous injury was just as likely in both settings. Additionally, they found that football had a considerably greater rate of injury in games compared to other sports and compared to practices. Finally, they report that injuries during games increased with a rise in age and years of experience [63].

Football has been demonstrated in many studies to have the highest incidence of injuries due to the high degree of contact between players. In several studies it has the highest rate of injury and highest length of post injury disability [17, 60, 62]. Powell and Barber-Foss
found football to have a 2.5 times higher rate of injury during competition than any other sport in the study [17]. However, one study found that basketball had the highest amount of ankle injuries with 50% of the players having ankle problems [64]. Tropp et al [33] reported that in soccer 11% of the athletes sprained their ankles for the first time and 25% sprained their ankle when they had a previous sprain [33].

Nelson et al [14] reported that football had a lower injury rate than men’s and women’s basketball, but football had the highest portion of high school injuries, followed by men’s and women’s soccer. Football accounted for 24.1% of all ankle injuries; with 81.8% of the injuries being new. Soccer was attributed to 33.6% of all ankle injuries. Ankle injuries were the most frequent injury in men’s and women’s soccer, but women had a higher proportion of ankle injuries to total number of injuries (31.5%) than men (23.5%). The men had 77.3% of injuries first time injuries, and 85.2% of women’s soccer injuries were new. Volleyball accounted for 10.6% of all high school ankle injuries, and had the highest proportion of ankle injuries, and basketball accounted for 23.8% of all ankle injuries [14].

Summary

The combination of comparisons between sex, sport, session (competition/practice), and bracing/taping of the ankle has yet to be examined in one study. While extensive data on each of the factors exists, to our knowledge no previous study has considered all of them in one study. Additionally, no previous studies have collected data in the Toledo, OH area, where extensive high school participation exists. All of these factors can be observed to establish how each can relate to injury rates, risk factors, and eventually determine prevention techniques at the ankle.
Chapter 3

Methods

Data Source

All data was collected from a certified Athletic Trainer at one of 9 high schools in Toledo, OH about the participation and injury rates of athletes ranging from 14-18 years old participating in the sports of volleyball, football, men’s and women’s soccer, and men’s and women’s basketball.

Procedures

The Athletic Trainers at each high school was contacted every week and asked to report the data from the previous week. The information collected was transferred to a data collection form (Appendix A) by the principal investigator and then entered into Excel spreadsheet for processing. The following injuries were monitored: Grade I lateral and medial ankle sprain, Grade II lateral and medial ankle sprain, Grade III lateral and medial ankle sprain, dislocation, Achilles tendon Grade I, Grade II, and Grade III or rupture, peroneal tendon injuries Grade I,
Grade II, and Grade II, and fracture.

**Statistical Analysis**

The number of the total injuries for each injury category listed on the questionnaire served as the dependant variables. Therefore, a total of 14 dependant variables were recorded. The independent variables included Sex (male, female), Sport (football, basketball, soccer, and volleyball), Session (practice, competition), and Condition (taped, braced, nothing). For each independent variable, we used pure descriptives, and reported the number of injuries for each dependant variable/injury category from the survey.
Chapter 4

Results

Football/Basketball/Soccer/Volleyball

Football and basketball had higher incidences of lateral ankle sprains grade I than volleyball and soccer, and basketball had more injuries than football. Football also had a higher amount of injuries in lateral ankle sprains grade II, fractures, and syndesmosis sprains. (Table 1) (Figure 1)

When all grades of lateral ankle sprains are combined, football and basketball are equal and have more injuries than volleyball and soccer which are equal to each other. Volleyball and football were even in incidences for all grades of medial ankle sprains. (Figure 2)

When the total number of ankle/foot injuries was considered for each sport, football had the most injuries. Basketball was next, and then there was a large drop off in the number of injuries in volleyball and soccer. (Figure 3)
Male/Female

Males had a greater number of incidences also in grade I and II lateral ankle sprains, fracture, and syndesmosis sprains compared with females. (Table 2) (Figure 4)

Males had a higher amount of injuries when all lateral ankle sprain grades were combined, and all peroneal grades were combined. Medial ankle sprains were equal between males and females. (Figure 5)

Overall, males had four times more injuries than females when all ankle/foot injuries were combined. (Figure 6)

Competition/Practice

There was a much higher amount of injuries during practice for grade I lateral ankle sprains, while grade II lateral ankle sprains were higher during competition. Fracture incidences were higher during practice, and syndesmosis sprain incidences were higher in competition. (Table 3) (Figure 6)

There was a higher amount of practice incidences for all lateral ankle sprains. Medial ankle sprains were higher during practice, while Achilles injuries were higher during competition. All grades of peroneal injuries were even for practice and competitions. (Figure 7)

There were higher numbers of ankle/foot injuries in practice than in competition when all injuries were combined. (Figure 8)
Ankle Tape/Ankle Brace/Nothing

There was a greater amount of incidences of grade I and II lateral ankle sprains, fractures and syndesmosis sprains with no support to the ankle compared to when the ankle had tape or a brace applied. There was only a slight increase in incidences of lateral grade I sprain for athletes when they were taped compared to when they wore braces. Conversely, more grade II lateral sprain were suffered while wearing a brace than when tape was applied. There were an equal number of fractures when taped or braced while and syndesmosis sprains were greater while wearing a brace compared to wearing tape. (Table 4) (Figure 9)

There was a much greater amount of incidences with nothing protecting their ankle for all lateral ankle sprains compared to taping and bracing; while taping having a slightly higher rate than bracing for incidence of LAS. Medial ankle sprains had an even number of incidences between tape and no protection. Achilles and peroneal injuries only occurred with no protection to the ankle. (Figure 10)

Overall, there was a higher amount of injuries to the foot/ankle in athletes with no protection. Bracing had the next highest amount of injuries, and tape was only slightly lower than bracing. (Figure 11)
Table 1: Sport and Injury Comparison

<table>
<thead>
<tr>
<th>Sport</th>
<th>LAS 1</th>
<th>LAS 2</th>
<th>LAS 3</th>
<th>MAS 1</th>
<th>MAS 2</th>
<th>MAS 3</th>
<th>Ach 1</th>
<th>Ach 2</th>
<th>Ach 3</th>
<th>Per 1</th>
<th>Per 2</th>
<th>Per 3</th>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Basketball</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<td>1</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
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<td>0</td>
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<tr>
<td>Fx</td>
<td>5</td>
<td>0</td>
<td>6</td>
<td>49</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1: Sport and Injury Comparison

![Figure 1: Sport and Injury Comparison](image-url)
Figure 2: Sport and Combined Injury Comparisons

![Bar chart showing sport and combined injury comparisons](chart.png)
Figure 3: Sport and Total Number of Ankle/Foot Injuries
Table 2: Sex and Injury Comparison

<table>
<thead>
<tr>
<th></th>
<th>LAS 1</th>
<th>LAS 2</th>
<th>MAS 1</th>
<th>MAS 2</th>
<th>MAS 3</th>
<th>Ach 1</th>
<th>Ach 2</th>
<th>Ach 3</th>
<th>Per 1</th>
<th>Per 2</th>
<th>Per 3</th>
</tr>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Fx</th>
<th>disloc</th>
<th>Synd</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
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<td>0</td>
<td>7</td>
<td>89</td>
</tr>
<tr>
<td>Female</td>
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<td>0</td>
<td>0</td>
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</table>
Figure 4: Sex and Injury Comparison
Figure 5: Sex and Combined Injury Comparison
Figure 6: Sex and Total Number of Ankle/Foot Injuries

![Bar graph showing the number of ankle/foot injuries by sex]

- Male: 90 injuries
- Female: 20 injuries
Table 3: Competition/Practice and Injury Comparison

<table>
<thead>
<tr>
<th></th>
<th>LAS 1</th>
<th>LAS 2</th>
<th>LAS 3</th>
<th>MAS 1</th>
<th>MAS 2</th>
<th>MAS 3</th>
<th>Ach1</th>
<th>Ach2</th>
<th>Ach3</th>
<th>Per1</th>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Fx  disloc  Synd  Total
5    0    2    62
4    0    5    47
Figure 7: Competition/Practice and Injury Comparison

- Practice
- Competition

Injuries:
- LAS 1
- LAS 2
- LAS 3
- MAS 1
- MAS 2
- MAS 3
- Ach 1
- Ach 2
- Ach 3
- Per 1
- Per 2
- Per 3
- Fx
- disloc
- Synd

# incidences
0 5 10 15 20 25 30 35 40 45 50
Figure 8: Competition/Practice and Combined Injury Comparison
Figure 9: Competition/Practice and Total Ankle/Foot Injuries
### Table 4: Protection and Injury Comparison

<table>
<thead>
<tr>
<th></th>
<th>LAS 1</th>
<th>LAS 2</th>
<th>LAS 3</th>
<th>MAS 1</th>
<th>MAS 2</th>
<th>MAS 3</th>
<th>Ach1</th>
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<th>Ach3</th>
<th>Per1</th>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>brace</td>
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<td>0</td>
<td>0</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fx disloc Synd Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1        0    0    12</td>
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<tr>
<td>1        0    1    16</td>
</tr>
<tr>
<td>7        0    6    28</td>
</tr>
</tbody>
</table>
Figure 10: Protection and Injury Comparison

![Bar graph showing the comparison of protection methods against various injuries. The x-axis represents different types of injuries (LAS 1, LAS 2, MAS 1, MAS 2, MAS 3, Ach1, Ach2, Ach3, Per1, Per2, Per3, Fx, disloc, Synd). The y-axis represents the number of incidences. The graph compares the use of tape, brace, and nothing as protective measures.]
Figure 11: Protection and Combined Injury Comparison
Figure 12: Protection and Total Ankle/Foot Injuries

![Bar chart showing the number of ankle/foot injuries with tape, brace, and nothing.](chart.png)
Chapter 5

Discussion

The purpose of this study was to examine how sex, sport, bracing, taping, and session (competition/practice) influence the injury rates of the ankle and foot among high school athletes in the Toledo, OH area. This was done by collecting injury data recorded by certified athletic trainers from 9 different area high schools. It was hypothesized that 1) females would have a higher incidence of injuries than males in soccer and basketball, 2) there would be less ankle injuries for athletes that were in a brace compared to taping and nothing at all, 3) football would have the highest rate of ankle injuries compared to the other sports included in this study, and 4) competition injuries would be more prevalent than practice injuries. The last two of the hypotheses were proven correct, and the first two were not supported.

Sport Differences

Not surprisingly, basketball and football had a higher number of incidences for each injury category, except for medial ankle sprains. For grade I lateral ankle sprains basketball and football were much higher than volleyball and soccer, with basketball having the most injuries. However, when all lateral ankle sprains are combined, football and basketball are equal to each
other. Also, when all the injury categories were combined, football had the most incidences in every injury category. This finding supports our hypothesis of football having the highest rate of ankle injuries.

The increase in injuries in basketball and football could be due to the increase in jumping and cutting required with each sport, and how close of proximity they are with other athletes when they make these motions. Football has the highest degree of contact with tackling and blocking, therefore it is not surprising that it has the highest amount of injuries overall [17, 60, 62].

Similar to this study football was the sport with the highest incidence in injury in multiple other studies as well [17, 60, 62]. Also one study found basketball to have the highest incidence of injuries [64]. Nelson et al. [14] also found that basketball injuries were more frequent in males than females.

**Sex Differences**

The differences between sexes were quite noticeable. Males had more injuries than females in every category except for grade one medial ankle sprains and grade II peroneal sprains, in which the two sexes were equal. This disparity between each sex could be contributed to the males having more contact sports than females. Football was the sport with the most injuries, and volleyball did not come close to having the same amount of injuries. The difference could also be attributed to the reality that athletic trainers at each high school traditionally spent more time in contact with the football teams than the volleyball teams, which may have influenced record keeping. Additionally, one of the high schools included in the study
has only male enrollment, which skews the total number of males and females included in the study. We did not track the total number of participants or exposures. Future investigation needs to include this information and attempt to provide a more even distribution of males and females if possible. The hypothesis that females will have more incidences in basketball and soccer was proven to be wrong in this study. One reason could be that not every school looked at in this study had female soccer.

The level of the female athlete in Toledo, OH for basketball was not very high in most of the schools. Emery [47] found that females were at risk for injury due to inexperience, and physiological changes compared to males. Also males were found to be at greater risk due to aggression, larger body mass, and more experience.

There was obviously disparity between males in females in the data collected in this study. However, other studies have found no differences between males and females ankle injuries [11, 39, 61]; while Leninger [48] found that females had 25% more injuries than males in soccer. The differences from this study I believe are due to the comparison of sex and sport. This study did not compare those two variables together. Also the previous studies used injury rates and not injury incidences. Because we used injury incidence and there were more males than females monitored in the injury data, it is not overly surprising that more total injuries occurred among males than females. However, this is still important information. If the reality is that more males are participating in higher risk sports in the city of Toledo than females and the males are experiencing more total injuries, this has critical implications for the health care of adolescent athletes in this particular city.
**Competition/Practice**

Overall, the number of injuries suffered during practice was greater than during competition. However, when looking at the specific injury categories, there is disparity of this influence. Practice injuries were much higher for lateral grade I ankle sprains; but grade II lateral ankle sprains and syndesmosis sprains were more prevalent during competition. In competition not only is the athlete working harder, but the competitor is playing with a higher intensity as well.

Different from this study many other studies have found there to be more competition injuries than practice injuries [14, 20, 21]. These studies found competition injuries to be more severe, but more in number as well. The difference may be due to them using injury rates instead of incidences. There are far fewer games than practices, so becoming injured during one game compared to one practice will affect the injury rates. Future investigations clearly need to include the injury rate per exposure to understand this factor.

**Protection**

Overall, the number of injuries was highest when the ankle was not protected with tape or brace. When comparing the number of incidences when the ankle was taped or braced, there were more grade I lateral ankle sprains with the ankle taped, but every other category had more injuries with braces or they were equal to each other. Our hypothesis was only partially supported because while the number of overall injury incidences was highest with no protection on the ankle, the second highest number of incidences occurred with a brace applied as opposed to ankle tape.
Sitler et al. [32] found a reduction of ankle injuries when the athlete was braced, and similarly Garrick [4] found a decrease of ankle injuries when the athlete was taped. Both tape and brace were shown to decrease ankle injury incidences for this study. Again, it will be important in the future to include the number of exposures so that injury rates can be calculated.

Limitations

A limitation to the study, as with any epidemiology study, is how complete and accurate the data set was. The data were compiled from weekly reports from the certified athletic trainers at the high schools from the injuries observed and managed during that week. Data were collected on the reporting form through email, but the forms did not always get returned consistently. Another limitation would be that each athletic trainer might have graded injuries differently. While all of the athletic trainers were certified and licensed in the state of Ohio, each one came from different backgrounds and different undergraduate programs, and have had many different athletic training experiences, which could have influenced the descriptions and categorizations of the injuries. Another limitation would be that the athletic trainers at each high school only traveled with their football teams. Perhaps this could have led to less injuries being reported at away games. Finally, we did not compile the total number of exposures or the total number of athletes. We recognize that this information is critical to determining the rates of injuries among all of the independent variables we selected. There are plans in the future to collect and compile this data as the faculty advisor continues to pursue this line of research, which will provide more accurate information.
Clinical Relevance

This study has demonstrated that football and basketball have a much greater incidence of injuries than soccer and volleyball, likely due to the higher amount of jumping and cutting in close proximity to other athletes. This is consistent with other previous studies. This study also showed that males have a much higher incidence of injury than females. There was a higher amount of total injuries during practice than competition, but the competition injuries were more severe. Also, having a brace or tape resulted in less ankle incidences. There were more injuries with braces than taping, but the difference were not by much.

Ankle injuries are a common consequence of participation in any high school sports. This study demonstrates there are sport, competition, sex, and protection ankle injury patterns that athletic trainers should be aware of to help them during diagnosis and treatment of the injury. Prevention of these injuries can happen by understanding the mechanisms and risk factors to ankle injuries.

Conclusions

Ankle injuries are the most common injuries sustained by high school athletes. More ankle injuries will present themselves as participation in high school sports increases. The evidence suggests that football and basketball have higher amounts of injuries, males are injured more than females, competition injuries are more severe than practice injuries, and taping and bracing were better than no protection with taping being slightly better than bracing. Future investigations need to continue this line of inquiry to provide a larger data set over
several years, as well as include the number of exposures so that the rate of injuries can be calculated.
References


Appendix A

Data Collection Form
Ankle Injury Data

Date of Injury: ____________            Practice       or       Competition

Sex:   M    F               Age: ______

Sport:   Football     Soccer     Volleyball     Basketball

Injury

Lateral Ankle Sprain:  Grade I Grade II Grade III

Medial Ankle Sprain:  Grade I Grade II Grade III

Dislocation:  Indicate Joint ____________________________

Achilles Tendon:  Grade I Grade II Grade III (rupture)

Peroneal Tendon:  Grade I Grade II Grade III

Fracture:  Indicate Bone ____________________________

Describe Mechanism of Injury:
__________________________________________________________________________________

Was Ankle Protected:  No       Yes-Taped       Yes-Braced

Was this the first time this injury was experienced:  Y   N

If no, how many times had this injury been experienced?    _____
Appendix B

IRB Waiver Form
MEMORANDUM DESIGNATING ACTIVITY “NOT HUMAN SUBJECT RESEARCH”
TO: Phillip Gribble, PhD, ATC, Assistant Professor, Department of Kinesiology
CC: Roland T. Skeel, M.D., Biomedical IRB Chair
UT Biomedical IRB
FROM: Sara L. Wisniewski, J.D., Director of Regulatory Compliance
DATE: March 27, 2009
RE: Sports Injury Data Collection – High School Athletes
We have reviewed your inquiry regarding your proposal to analyze data collected by athletic
trainers at Toledo area high schools regarding the number of foot and ankle injuries in
each sport
during the previous two seasons. According to the information that you provided, your
activities
will not include interactions or interventions with the athletes, and the data that you will
analyze
will not contain information that could identify the individuals.
It is our determination that your proposed activity does not meet the definition of research
involving “human subjects” under 45 CFR 46 because although you will obtain data
about living
individuals, (1) you will not obtain data through interaction or intervention with the
individuals, and
(2) the identity of the individual subjects is not or cannot be readily ascertained or
associated with
the information that will be provided to you. The human subject protection regulations at
45 CFR
46 do not apply to this type of research and therefore IRB review and approval is not
required for
your activity.
Thank you for your inquiry. You may proceed with your activity without further review
from the
IRB unless modifications are made to the project that might bring your activity within the
scope of
human subject research (e.g. interaction with the individuals about whom you are
obtaining
information or receipt of individually identifiable information about them).
Please contact Sara Wisniewski at sara.wisniewski@utoledo.edu if you have additional
questions or
would like further clarification.
1 Human subject means a living individual about whom an investigator (whether professional or student)
conducting
research obtains (1) data through intervention or interaction with the individual, or (2) identifiable private
information.
45 CFR 46.102(f).
2 In the event research is undertaken without the intention of involving human subjects, but it is later
proposed to
involve human subjects in the research, the research shall first be reviewed and approved by an IRB. 45
CFR 46.119