

THE IMPACT OF ANKLE SPRAIN AND CHRONIC ANKLE INSTABILITY ON
ADOLESCENTS' PHYSICAL ACTIVITY LEVELS

A Thesis
by
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Abstract

THE IMPACT OF ANKLE SPRAIN AND CHRONIC ANKLE INSTABILITY ON ADOLESCENTS' PHYSICAL ACTIVITY LEVELS

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The effect of ankle sprain and chronic ankle instability on adolescents' physical activity (PA) levels has received limited attention from researchers. Majority of prior research about ankle sprain and chronic ankle instability has been conducted on mouse injury models and limited human studies. Research has shown that in adults, about 60% have an ankle injury with about a quarter of those having ongoing problems. Ankle injuries create a significant estimated financial burden of 2-4 billion dollars in the United States. The purpose of the current study is two-fold: 1) quantify the prevalence rate of ankle sprain and functional ankle instability among adolescents in a rural area; 2) compare the PA levels of adolescents in four groups those with no history of ankle injury (uninjured), those with a history of ankle injury and no functional ankle instability (coper), those with a history of injury and functional instability for less than a year (potentially unstable), and those with both a history of ankle injury and functional ankle instability for more than one year (unstable). A total of 369 adolescents aged 14-19 years submitted a self-administered and 201 surveys were analyzed. The survey was completed online and assessed demographic information, history of ankle injury, and PA levels. One hundred fifteen respondents (57.2%) reported a history of ankle sprain and injury (males 56.3%;

females 58.3%). Of these respondents, 40 individuals (19.9%) reported a history of injury within the past year. Of respondents more than a year from injury, 59 (78.6%) reported chronic ankle instability and 16 respondents (21.3%) met criteria of ankle copers. Significant differences in PA level were seen between those who reported to have no injury and those who reported to have unstable ankles ($\chi^2_4 = 11.65, p < 0.01$). Post hoc tests revealed unstable respondents reported more PA than uninjured respondents (unstable = 4706.05 ± 4610.56 MET-minutes/week; uninjured = 2592.93 ± 2946.02 MET-minutes/week), with no differences between other groups. Possible explanations as to why the unstable participants engaged in more PA than the uninjured participants involve different modes of PA and perception of pain. Participants that have a history of ankle injury reported engaging in more high impact activities such as running, jogging, and team sports than the uninjured group. In addition, since ankle sprains may be viewed as a minor injury and the adolescents of the current study may have little to no fear of re-injury thereby quickly returning to PA.

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Chapter 1: Introduction

Physical activity (PA) behaviors and habits seem to develop through sports and recreation in childhood (Malina, 1996). PA tends to decline with age starting in adolescence, especially among females, which can lead to increased health risks (Sanchez et al., 2007). Physical inactivity is associated with increased risk of all-cause mortality and a range of chronic diseases such as heart disease, obesity, diabetes, asthma, certain types of cancer, and negatively impact mental health (Koyuncuoğlu Güngör, 2014; Lee & Skerrett, 2001; McPhie & Rawana, 2015; Paffenbarger, Hyde, Hsieh, & Wing, 1986).

Limited studies have been conducted on humans to determine the prevalence rate of ankle injury and subsequent chronic ankle issues and effects on PA. PA has been shown to decline as an individual ages and chronic ankle instability (CAI) has also been linked with a decrease in PA. Hiller et al. (2012) found that 60% of the Australian population aged 18-64 had reported suffering an ankle injury with one quarter of those reporting ongoing ankle-related problems with many participants reported decreasing or changing their PA patterns. Among an athletic population over 60% of athletes reported a previous ankle sprain and 23.4% of participants reported CAI (Tanen, Docherty, Van Der Pol, Simon, & Schrader, 2013). In the United States, incidence rates from emergency room visits were calculated and peak incidence of ankle sprain was seen in those aged 15 to 19 years with nearly half (49.3%) of the ankle sprains due to athletic activity (Waterman, Owens, Davey, Zacchilli, & Belmont, 2010). Males aged 15-24 years had a higher incidence of ankle sprains compared to females of that age (Waterman, Owens, et al., 2010).

Ankle injury consequently creates an economic burden on global health care systems. In 2010, lateral ankle sprains cost about \$1,008/incident and medial ankle sprains cost about \$914/incident in the United States (Shah, Thomas, Noone, Blanchette, & Wikstrom, 2016). Given reports that 250,00 to 500,000 ankle sprains are reported in United States emergency rooms each

year, the estimated economic burden can amount to \$2-4 billion per annum in just the United States (Waterman, Owens, et al., 2010). This number does not account for the continuum of life-long consequences such as disability and a decreased quality of life that can result from ankle sprains (Gribble et al., 2016; Wikstrom, Hubbard-Turner, & McKeon, 2013). CAI or the sensation of giving way or rolling or twisting of the ankle during PA, and an increased risk of early onset post traumatic osteoarthritis can contribute to long-term deficits and require increased medical cost (Hintermann, Boss, & Schäfer, 2002; Robinson & Keith, 2016). Furthermore, the symptoms such as instability and pain that are associated with these sequelae have the potential to limit PA, potentially increasing the likelihood of all-cause mortality, heart disease, obesity, and diabetes (Koyuncuoğlu Güngör, 2014; Lee & Skerrett, 2001; McPhie & Rawana, 2015; Paffenbarger et al., 1986).

Few studies have described the future implications ankle injury can have on PA. College students that suffered from CAI reported a decrease in PA levels, measured by average step count, compared to college students with no lower limb injury history (Hubbard-Turner & Turner, 2015). The impacts of ankle sprains and instability on PA levels throughout the lifetime have been shown in an injury mouse model, and demonstrated that mice who sustained an ankle injury ran significantly less per day as well as at a lower intensity (Hubbard-Turner, Wikstrom, Guderian, & Turner, 2015). The impact of ankle sprains and CAI on adolescents' PA levels have not been studied, and therefore leaves a gap in the research. Determining the prevalence of ankle injury and CAI and understanding the potential effects on adolescents' PA levels may help to focus public health efforts on increasing awareness of the severity of ankle injuries and seeking proper treatment.

The purpose of the current study is to first determine the prevalence of ankle sprain and ankle instability among adolescents in a rural county in North Carolina and second to compare PA levels across adolescent's ankle status. PA level was compared across four groups: 1) those with no history of ankle sprain or instability (uninjured); 2) those with a history of ankle sprain and no reoccurring ankle instability (coper); 3) those with both a history of ankle sprain and ankle instability for less than one year (potentially unstable); 4) those with both a history of ankle sprain and ankle instability for

more than one year (unstable). As standards suggest that determinations for copers or unstable require individuals be more than one year from injury, a group of those injured within the past year and showing sign of instability was included (potentially unstable) (Gribble et al., 2014). It is hypothesized that adolescents that suffer from an ankle sprain will engage in less PA than those that have not sustained a sprain. In addition it is hypothesized that PA levels will decline with increasing degree of ankle instability with the unstable group having lower PA levels than the potentially unstable group which will subsequently have lower levels than the copers.

Chapter 2: Review of Literature

Epidemiology of Ankle Sprains and CAI

Few epidemiological studies have focused on ankle sprain and instability and so far the evidence suggests that a significant portion of the population suffers from ankle sprain and instability. Such studies include an Australian population, a college cohort, the U.S. Military Academy, and an athletic population. In Australia, a computer aided telephone survey of those aged 18-65 reported 60% had sustained an ankle injury, 45% had a history of ankle injuries but no chronic issues such as the feeling of “giving way”, and 24% had chronic ankle disorders which would include the feelings of “giving way” and reoccurring ankle sprains (Hiller et al., 2012). In addition to feeling of giving way those individuals that reported chronic musculoskeletal disorder of the ankle also reported having to limit or change their PA patterns. A study conducted in the United States, similar to the one conducted in Australia, on a college cohort had participants complete self-reported questionnaires and wear a pedometer daily for one week. The study found that college students with a mean age of 20.4 years suffering from CAI took fewer steps than those that reported no injury (Hubbard-Turner & Turner, 2015).

Previous studies involving ankle injuries have been conducted primarily on an athletic population. Among high school and collegiate athletes’ sports related injuries, ankle ligament sprains were the most common injury reported (Fernandez, Yard, & Comstock, 2007; Hootman, Dick, & Agel, 2007). Another study conducted on high school and collegiate athletes concluded that more than 23% athletes had reported chronic ankle instability (Tanen et al., 2013). Tanen et al. (2013) also reported that high school athletes tended to have a higher prevalence of CAI as well as females had a higher prevalence of CAI compared to males. Among the United States Military Academy over a two-year period showed that ankle sprains were the highest injury sustained at 78% and the average

time loss due to a lateral ankle sprain was eight days (Waterman, Belmont, Camerson, DeBerardino, & Owens, 2010).

Ankle Injuries in Healthcare

Ankle injuries are prominent across the life span and may need treatment by a physician. Various studies about health care costs of ankle injuries have been conducted outside of the United States. In Victoria, Australia reports that overall sports injuries treated in the hospital increased by 24% and lower limb injuries increased by 26% over the years from 2004-2010 (Finch, Kemp, & Clapperton, 2015). The associated accumulated economic burden was \$265 million for all sports injuries and \$110 million for lower limb injuries over the seven-year period. Further research in the Netherlands suggests that health care costs for boney injuries of the ankle and foot were about 3,461 euros (\$3,653 USD) with costs tending to increase with age for females to about 10,949 euros (\$11,556 USD) and males to about 6,023 euros (\$6,357 USD) (De Boer, Schepers, Panneman, Van Beeck, & Van Lieshout, 2014). De Boer et al. (2014) noted that these costs took into account in-hospital care, rehabilitation/nursing care, and physical therapy. . A study conducted in 2010 found that the average cost per emergency room visit in the United Sates for a lateral ankle sprain was \$1,008/incident and for a medial ankle sprain was about \$914/incident (Shah et al., 2016). In addition, females had a higher incidence rate of ankle sprains than males and the age group of 18-25 year olds had the most emergency room visits. When combining multiple studies reported health care cost, follow-up health care costs, work time loss, and prevalence of ankle injuries the estimated accumulated economic burden can be as high as \$2-4 billion.

To diagnose ankle injuries, x-rays or radiographs can be costly and therefore some ideas to alleviate the cost have been developed. The low risk ankle rule, now known as the Ottawa Ankle Rule, was developed to help alleviate the costs by as much as \$36.93 less per patient at intervention compared with control sites (Boutis et al., 2015). The Ottawa Ankle Rule indicates that if a child presents with tenderness and swelling isolated to the distal fibula or adjacent lateral ligaments distal to the tibial anterior joint line (low-risk examination), then a radiograph may not be necessary for the

detection of a clinically important ankle injury (Boutis et al., 2015). Canadian emergency departments participated in the Ottawa Ankle Rule and their overall implementation of this rule reduced the rate of pediatric ankle radiography significantly and safely without impeding physician or patient satisfaction (Boutis et al., 2013). This technique also showed a 22.9% reduction in ankle radiography, especially those that were unnecessary for children (Boutis et al., 2015).

Long Term Impact of Ankle Sprains

Ankle sprains may lead to a continuum of life-long consequences such as disability and a decreased quality of life (Wikstrom et al., 2013). Such long term consequences include change in a person's gait, the ability to effectively absorb forces, and maintain a stable base of support (Hoch, Mullineaux, Kyoungkyu Jeon, & McKeon, 2016). It is still of question if specific motor patterns of the ankle are impacted due to CAI. Those with CAI demonstrated greater ankle inversion following toe-off (Doherty et al., 2016b; Moisan, Descarreaux, & Cantin, 2017; Willems, Witvrouw, Delbaere, De Cock, & De Clercq, 2005). Due to greater inversion and increased load on lateral part of foot the individual may be predisposed to episodes of "giving way" (Moisan et al., 2017). An individuals' gait that had a lateral situation center of pressure during initial contact in gait had a higher risk of sustaining an inversion ankle sprain (Willems et al., 2005). In addition to gait implications postural control in the single limb stance has been shown to be hindered in those that suffer CAI (Kyung-Min Kim, Hart, Saliba, & Hertel, 2016). Doherty et al. (2016a) compared dynamic balance among controls, copers, and CAI individuals, and found that those with CAI demonstrated lack of dynamic balance. CAI has the potential to alter kinetics, kinematics and motor control that can put an individual at risk for repeated ankle injury.

In addition to gait change arthroscopic data on the structural changes of chronically unstable ankles showed the degenerative nature of arthritis after CAI such as intra-articular lesions that might cause chronic pain, disability, and instability (Hintermann et al., 2002). Structural changes were found such as lesions of the cartilage and the lateral and medial ligaments. Hinterman et al. (2002) observed that 64% of the ankle sprains occurred during a sporting event. In a study of long term

follow-up after patients sustained an inversion ankle injury due to athletic participation only 26% of participants had fully recovered, leaving over 70% with persisting residual symptoms of CAI (Anandacoomarasamy & Barnsley, 2005). Inversion ankle sprains happen when the toes roll in and the outer lateral ligaments of the ankle are injured.

Inappropriate treatment of CAI can potentially be a substantial health risk (Hubbard-Turner & Turner, 2015). After the trauma of the injury itself, development of osteoarthritis is likely with 66-78% of ankle injuries leading to cartilage and ligament damage (Hintermann et al., 2002; Hirose, Murakami, Minowa, Kura, & Yamashita, 2004). Ultimately CAI can lead to a decrease in physical activity as shown in two studies, one reported a decrease in PA in adults, and another reported a decrease in step in a college population (Hiller et al., 2012; Hubbard-Turner & Turner, 2015).

Correlates of Physical Activity in Adolescents

PA declines dramatically between childhood and adolescence and continues to decline with age (Troiano et al., 2008). In a review of correlates of PA of children and adolescents, age was found to be negatively correlated with PA in 19 of 27 studies (Sallis, et al., 2000). As a child ages into adolescence their PA levels tend to decline. In addition to age, sex has been shown to be a correlate of adolescents' PA levels. In a brief review of 60 papers addressing PA and sedentary behaviors in youth (age 4-12) and adolescents (age 13-18 years), there was an association between PA and sex with males being more physically active than females (Van Der Horst, Paw, Twisk, & Van Mechelen, 2007). Close friends or friendship groups' PA levels have been shown to correspond with the level of PA of the individual (Cheng, Mendonça, & Farias Júnior, 2014; Sawka, McCormack, Nettel-Aguirre, Hawe, & Doyle-Baker, 2013). In a study by Van Der Horst et al. (2007) psychological, cognitive, and emotional factors (self-esteem, attitude, and perceived benefits) as well as social and cultural factors (parental encouragement and support) were all positively correlated with adolescents' PA levels (Van Der Horst et al., 2007). Socioeconomic status has also been found to influence PA levels of adolescents with lower socioeconomic status being linked to lower PA levels (Hanson & Chen, 2007).

Physical Activity and Injury

Among adolescent males have consistently been reported to engage in more physical activity than females (Sallis et al., 2000; Sanchez et al., 2007; Strauss, Rodzilsky, Burack, & Colin, 2001; Troiano et al., 2008). As indicated, physical activity seems to decrease starting at a young age due to various reasons, in addition peak injury ankle sprain occurs in males aged 15-19 years and males aged 15-24 years had a higher incidence of ankle sprains compared to females of that age (Waterman, Owens, Davey, Zacchilli, & Belmont, 2010). In a study of 11-17 year olds, males sustained a higher rate of injury than females, and males of a rural environment had a higher rate compared to males of an urban environment (Riley et al., 1996). Youth that lived in a rural setting sustained more major and minor injures than urban youth (65% and 53% respectively) (Riley et al., 1996). Alcohol use and high sports participation were associated with increased risk of injury in rural youth (Riley et al., 1996).

The Effect of Ankle Injury and CAI on Physical Activity

Due to the limited studies on humans, mouse injury models have been shown to be comparable to humans. Chang et al. (2016) discovered that 91% of mice had suffered from osteoarthritis within eight weeks post lateral ligament damage. In another mouse injury model, mice were split into three different groups, the mice that sustained a single sprain had a significant decrease in PA compared to mice without sprain (Hubbard-Turner et al., 2015).

Ankle injuries and CAI may have the potential to greatly impact PA and daily activities. A previous study demonstrated that when pedometers were used to assess PA, activity decreased in those who had suffered from CAI (Hubbard-Turner & Turner, 2015). In an adult population chronic musculoskeletal ankle disorder affected 20% of the overall Australian population, mostly due to a previous ankle injury, with many having to limit or change their physical activity because of the disorder (Hiller et al., 2012). A study by Andrew et al. (2014) found that among adults who participate in sports and recreational activities, a significant reduction in PA was reported 12 months post injury. In a long-term follow up study on patients of all ages after sustaining inversion ankle sprain were conducted and 39% (225 out of 577) reported residual complaints (pain, fear of giving-

way, instability, swelling) (Verhagen, De Keizer, & Van Dijk, 1995). Houston et al. (2014) compared uninjured individuals to individual that suffer CAI and found that the CAI group reported decreased function and increased fear of re-injury. Numerous researchers have concluded that there is no such thing as "a simple sprain" (Verhagen et al., 1995; Wikstrom et al., 2013).

An inverse relationship exists between physical activity and age, especially between childhood and adolescence (Troiano et al., 2008). This decline in physical activity can be the result of many factors including those related to gender, injury, and sports participation. CAI and ankle sprains in sport cohorts have been found to negatively impact physical activity levels (Andrew et al., 2014). Previous research has been conducted in a college population, the general population of Australia, and in mouse models as to how physical activity is affected by ankle sprains and CAI. Existing research in regards to injuries has been predominately studied in a sport cohort.

Chapter 3: Methods

Study Design and Data Collection Procedures

A cross-sectional study design was used. Participant recruitment and data collection took place between November 2016 and January 2017. Parental consent and minor assent was obtained from each participant. Potential participants were recruited directly from a high school in rural western North Carolina. All study procedures were developed with the high school administration and approved by the university institutional review board (16-0264). Initially, a passive parental consent form was sent home with all students by the high school. Parents had one full week to have their child return the signed passive consent form if they did not want their child to participate in the study. An email was then sent to all potential participants with minor assent language and a link to the online survey. All students enrolled at the high school are provided a laptop and email address by the school district during their first year. During data collection two reminder emails with a link to the online survey were sent. The survey took participants about 12 minutes on average to complete. Upon completion of the survey, participants were presented with an option to submit their email address for an equal opportunity chance to receive one of twenty \$25 Amazon gift card. The online survey was developed using Qualtrics software (Qualtrics, Provo, UT). About 1,400 emails were sent out, a total of 369 surveys were submitted and 201 were analyzed from males and females 14-19 years old. Of the 369 surveys 168 were discarded due to incompleteness of survey.

Measures

The survey consisted of three instruments including an injury history questionnaire, the Identification of Functional Ankle Instability (IdFAI) instrument and the International Physical Activity Questionnaire (IPAQ). See Appendix C for the IdFAI and Appendix A for the IPAQ. The injury history questionnaire consisted of five questions asking the participant about lower limb and ankle injuries, type of injury, care and diagnosis, and any treatment.

CAI status

The injury history questionnaire and IdFAI were used to determine CAI status to categorize participants into groups for comparison of PA level. The IdFAI has a high test-retest reliability with an intraclass correlation coefficient of 0.978 with Cronbach's alpha >0.9 (Gurav, Ganu, & Panhale, 2014; Simon, Donahue, & Docherty, 2012). The IdFAI was scored on a scale of 0-5 for each question in regards to the participants' left and right ankle, with higher scores indicating increased levels of instability. Participants were classified into 4 groups in accordance with International Ankle Consortium standards: 1) uninjured (no history of ankle sprain); 2) copers (history of sprain and IdFAI ≤ 10); 3) potentially unstable (history of ankle sprain within the past year and IdFAI ≥ 11) and; 4) unstable (history of sprain greater than one year and IdFAI ≥ 11) (Gribble et al., 2014).

PA levels

The IPAQ short form was used to quantify seven day recall self-reported PA levels. The IPAQ short form has been demonstrated to be reliable and valid for college age populations (Dinger, Behrens, & Han, 2006). The IPAQ short form is an established instrument for measuring self-reported PA levels for population monitoring (Spearman's ρ cluster = 0.8) (Craig et al., 2003). Participants entered the number of days per week and minutes per day they engaged in various activities ranging from walking to vigorous PA. The amount of time reported for each activity was multiplied by the amount of days the activity was performed. Then total amount of time for each activity was multiplied by a specific MET amount respective of each representative task. The MET amounts used were from the IPAQ scoring protocol. The total MET minutes reported were summed for each participant and used to analyze the total amount of physical activity the participant engaged in over the course of seven days (MET-minutes/wk) and used as a continuous variable.

Type of PA

A youths' outdoor participation survey was also included in analysis, utilizing items from the United States Department of Agriculture Forest Service National Kids Survey (Larson, Green, & Cordell, 2011). This portion of the survey consisted of various questions comparing time spent

outdoors this year to the previous year as well as what may hinder the participant from spending time outdoors. Additionally the survey included questions about what activities the participants engaged in outdoors during the past week. This questionnaire was also used to analyze the types of PA the participants engage in other than high school sports.

Statistical Analysis

Data analysis was conducted using IBM SPSS Statistics for Macintosh, version 24 (IBM Corp., Armonk, N.Y., USA). Univariate analysis of variance (ANOVAs) were used to compare continuous variables (BMI, PA) across the four groups. PA levels did not meet assumptions for parametric statistics and was therefore subsequently assessed across groups using a Kruskal-Wallis test. Categorical variables (age, sport participation, recreational status) were compared across groups using chi-square analysis. An independent t-test was used to compare PA and sex. All analyses were conducted at the alpha level set at $p < 0.05$.

Chapter 4: Results

The mean age of the participants was 15.8 ± 1.2 years. Table 1 displays the demographic characteristics of the participants. Sixty percent of the participants were females and 94% were white Caucasian. The highest level of education that parents of participants have attained indicate that participants were from mostly well-educated families with over 70% having a college degree.

Out of 201 participants, 115 (57.2%) reported a history of ankle sprain (males 56.3%; females 58.3%). Of the respondents indicating ankle sprain history, 40 (19.9%) reported a history of injury within the past year. See figures 1, 2, and 3 for details of ankle grouping. Of participants more than a year from injury, 59 (78.6%) reported CAI ($\text{IdFAI} \geq 11$), and 16 (21.3%) met the criteria of ankle copers ($\text{IdFAI} \leq 10$) all shown in table 2.

Table 1

Demographic Participant Characteristics

	<i>n</i>	%
Sex		
Male	80	39.8
Female	120	59.7
Did not disclose	1	0.5
Age		
14	33	20.2
15	38	23.3
16	46	28.2
17	36	22.1
18	8	5.0
19	2	1.2
Race/Ethnicity		
Asian/Pacific Islander	7	3.5
Black/African American	4	2.0
Hispanic or Latino	9	4.5
Native American/American Indian	6	3.0
White/Caucasian	189	94.0
Other	2	1.0

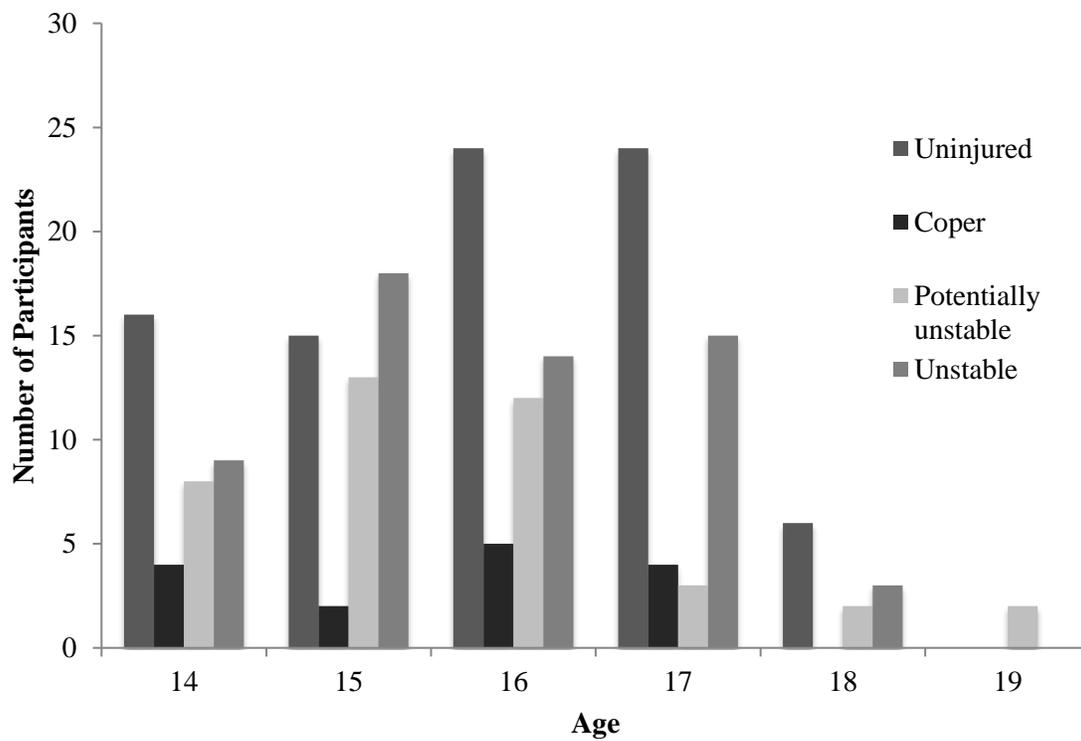


Figure 1. Ankle Injury Groups by Age.

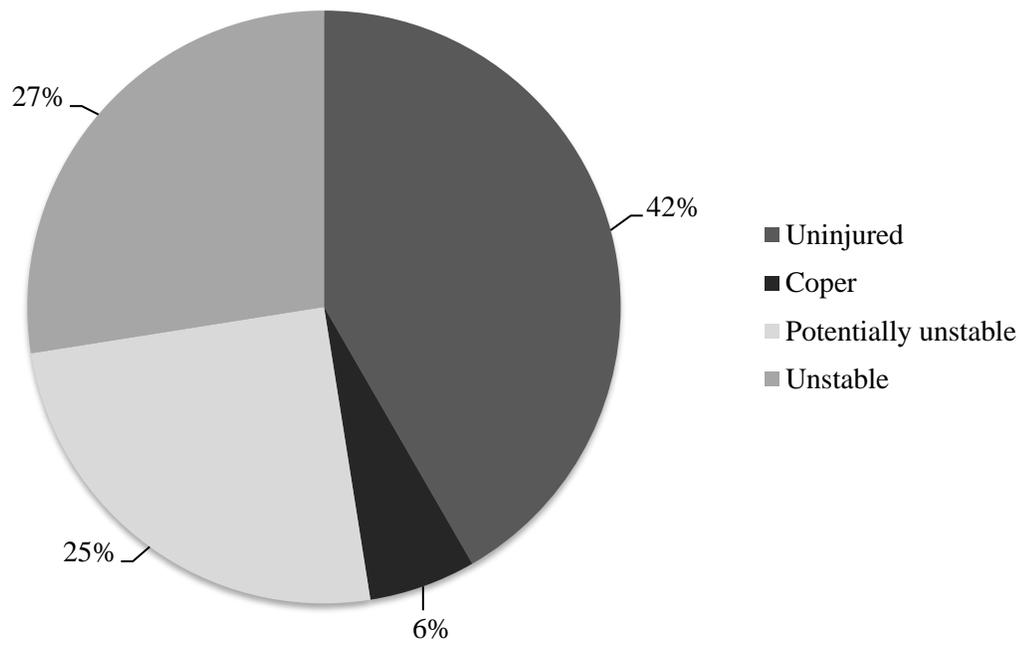


Figure 2. Female Ankle Injury Groups.

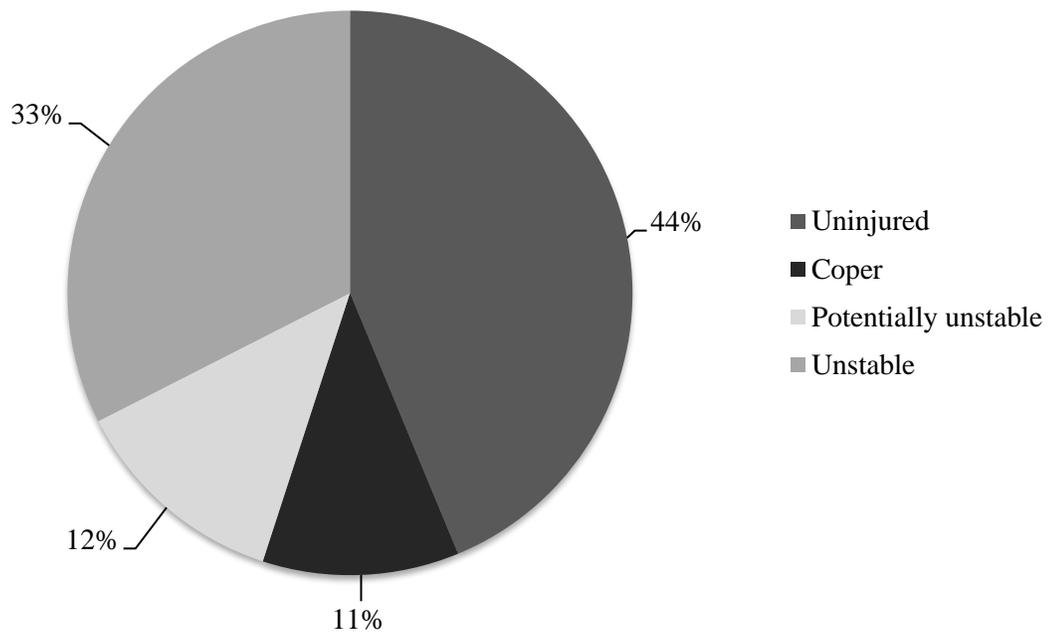


Figure 3. Male Ankle Injury Groups.

Table 2

Ankle Injury Groups

Groups	<i>n</i>	%
Uninjured	86	42.8
Coper	16	8.0
Potentially unstable	40	19.9
Unstable	59	29.4

No significant difference was observed in total MET-minutes/week reported according to age ($F_{(5,157)} = 1.49, p = 0.194$) shown in figure 4. A significant difference was observed between sex and total MET-minutes/week reported ($t(162) = 2.5, p = 0.036$) as seen in figure 5, with males reporting more total MET-minutes/week than females (males= 4344.82 ± 4124.1 MET-minutes/week; females= 2915.58 ± 3113.84 MET-minutes/week). Groups were not significantly different for participation in high school sports ($\chi^2_4 = 4.38, p = 0.22$); however respondents with a history of ankle injury reported greater participation in jogging and running activities ($\chi^2_3 = 3.99, p = 0.04$); team sports ($\chi^2_3 = 8.37, p < 0.01$); and motor sports ($\chi^2_3 = 4.99, p = 0.03$). Chi-squared analysis revealed no significant differences in frequency of injury across ages ($\chi^2_7 = 0.18, p = 0.27$). No differences in body mass index (BMI) were observed across groups ($F_{(3,185)} = 0.41, p = 0.74$). Statistically significant differences were detected between groups for total MET-minutes/week ($\chi^2_4 = 11.65, p < 0.01$); shown in Figure 6. Post hoc test with Bonferroni correction revealed unstable participants reported significantly more physical activity than uninjured participants (unstable= 4706.05 ± 4610.56 MET-minutes/week; uninjured= 2592.93 ± 2946.02 MET-minutes/week), with no differences between other groups shown in Table 3.

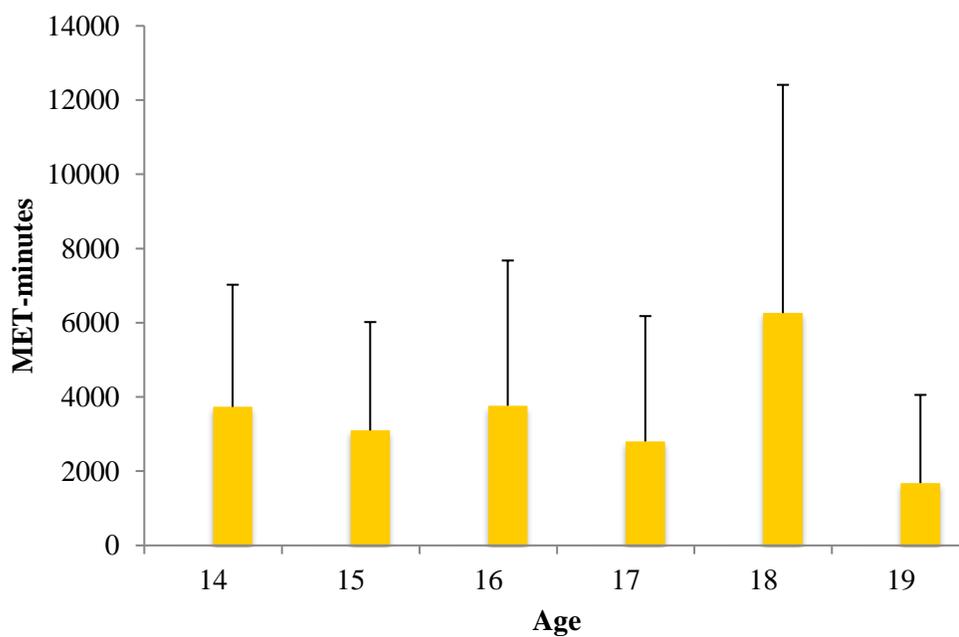


Figure 4 MET-minutes per week by Age. No significant difference. Standard deviation bars shown. $p = 0.194$.

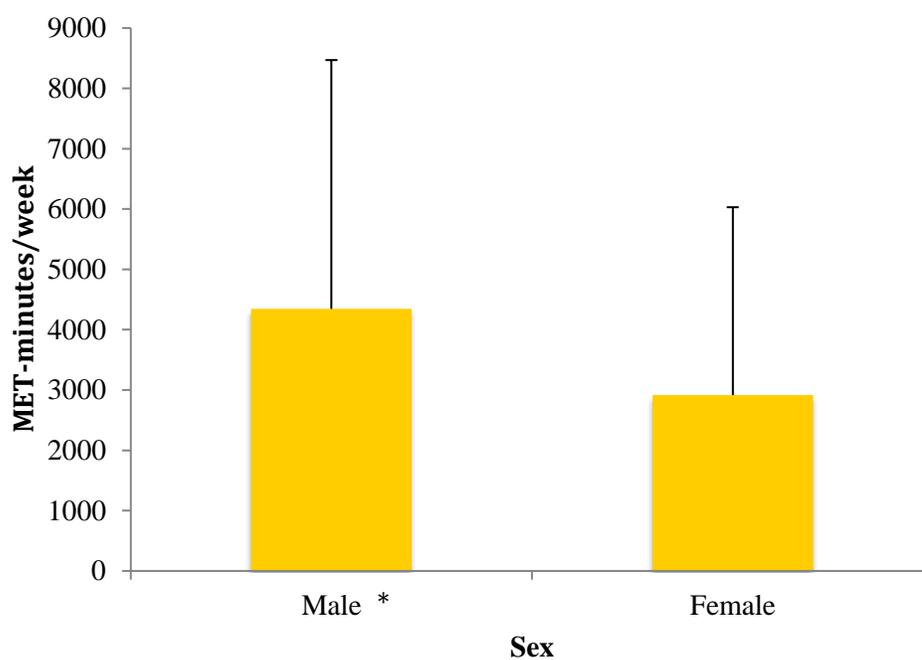


Figure 5. MET-minutes per week by Sex Males reported more physical activity than females. Standard deviation bars shown.* $p = 0.036$.

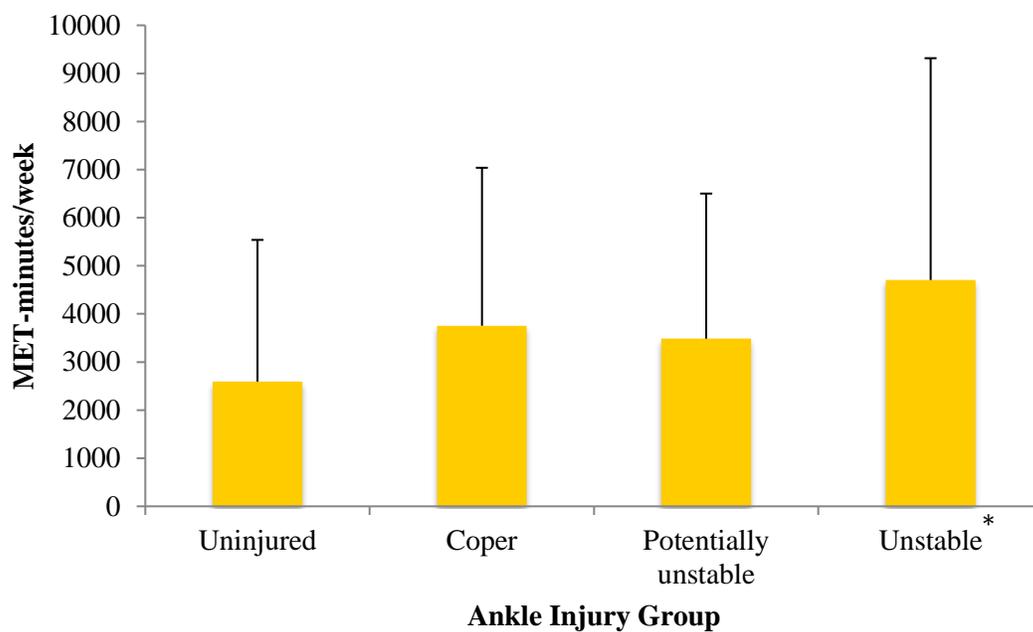


Figure 6. MET-minutes per week by Ankle Injury Group. Unstable participants reported more PA than uninjured participants. Standard deviation bars shown. * $p < 0.01$.

Table 3

MET-minutes/week by Ankle Injury Groups

Group	MET-minutes/week	SD
Uninjured	2592.93	2946.02
Coper	3754.15	3284.05
Potentially unstable	3465.01	3017.03
Unstable	4706.05*	4610.56

* $p < 0.01$.

Chapter 5: Discussion and Conclusion

The prevalence of CAI among adolescents reported in the current study were slightly lower than prevalence rates found in previous studies conducted among adults (Hiller et al., 2012; Tanen et al., 2013). After categorizing the sample into four groups based on history of ankle injury and CAI those that were unstable reported significantly more total MET minutes/week than the uninjured participants. This finding, that participants with CAI engage in more PA than respondents that were uninjured, is contrary to the study hypothesis and contradicts the results of a previous study conducted on a college age population (Hubbard-Turner & Turner, 2015). Respondents that had a history of ankle injury reported participation in more high impact activities such as running, jogging, and team sports. BMI was found to not be different among the groups and total MET-minutes/week reported did not differ by age.

Prevalence rates of ankle injury among an adult Australian population reported that 60% of participants had a history of ankle injury and 24% had reported CAI (Hiller et al., 2012). A previous study conducted with high school and collegiate athletes also reported over 60% of athletes had a history of ankle injury and about a quarter of athletes reported CAI (Tanen et al., 2013). In the current study, adolescents' reported similar findings with 57% having a history of ankle injury and about 29% having CAI. Therefore, there appears to be comparable rates of ankle injury history and CAI the ages of adolescence and adulthood as well as athletes. The similar rates of ankle injury history may imply that adolescence is a high-risk age for sustaining ankle sprains. It is unclear as to why there is no difference in reporting of ankle injury between adolescents and adults even though you would expect adults would report a higher prevalence of ankle injury than adolescents due to having more years of life and therefore more chances to sustain an ankle injury. In addition no difference in ankle injury history was seen between males and females of the current study contrary to what Watermen et al. (2010) had reported, with males reporting more ankle injuries than females aged 15-24. The finding that males of this study did not report a higher amount of ankle injury history is surprising

since males typically experience more injuries than females (Riley et al., 1996). However males engaged in more PA than females as is consistent with other studies (Sallis et al., 2000; Sanchez et al., 2007; Strauss et al., 2001; Troiano et al., 2008).

The findings of the current study do not support the original hypothesis that adolescents who suffer from an ankle sprain will engage in less PA than those who have not sustained a sprain. In the current study it is unclear why the unstable group reported higher levels of PA than the uninjured group. Similarly, these results do not support comparable results from Hubbard-Turner et al. (2015) that patients with an ankle sprain and CAI perform less PA. However, this data did not demonstrate a dose-response relationship between severity of ankle function and PA level. Several differences exist between the current study and previous research, including the population of rural adolescents and the use of self-reported PA questionnaires rather than accelerometry-based measures. Accelerometers are an objective measurement of PA where as self-reported PA is subjective. One comparison study on accelerometers and the IPAQ short form concluded that although the IPAQ short form has acceptable criterion validity the IPAQ short form may over estimate self-reported PA compared to accelerometers (Ekelund et al., 2006). Due to the large potential participant population of the current study (1,400 high school students) the IPAQ short form was a more feasible measurement tool to use in assessing PA compared to using accelerometers.

Another possible explanation for the higher levels of PA in the unstable group compared to the uninjured group is the potential lack of fear of re-injury among adolescents. While other studies have reported lower PA levels among adults with history of ankle injury and CAI (Hiller et al., 2012; Hubbard-Turner & Turner, 2015), adolescents may not reduce their PA due to CAI because of a decreased perception of future complications stemming from the injury. A study conducted on athletes at the high school and collegiate levels concluded that more than half of the sample reported no fear of returning to their sport after sustaining an injury that resulted in a loss of playing time (any injury, resulting in a loss of playing time not only ankle injuries) (Covassin, McAllister-Deitrick,

Bleecker, Heiden, & Yang, 2015). Subsequently, another study showed that for adolescents pain was not a significant indicator of PA levels (Rabbitts, Holley, Karlson, & Palermo, 2014).

We hypothesize that the reported high levels of PA may be leading to subsequent injuries specifically of the ankle and sensations of “giving way” or “rolling” of the ankle among those with injury history. Participants that have a history of ankle injury reported engaging in more high impact activities such as running, jogging, and team sports than the uninjured group, which corresponds with the study conducted by Guddal et al., (2017). Guddal et al., (2017) also discovered that participants of team sports were associated with increased odds of lower extremity pain. Similar findings comparing athletes that engage in more strenuous activities versus patients that engaged in less strenuous activities reported a higher percentage of residual complaints such as CAI symptoms (Verhagen et al., 1995).

To our knowledge no previous studies evaluated ankle injury and PA levels among adolescents to compare to the current study’s findings. Participants of the unstable group also reported engaging in more strenuous activities.

Limitations of this study include a small sample size and restriction of one high school population that limits the power and ability to generalize the findings of the current study to larger population. Recall bias due to self-reported PA levels could have affected the amount of PA reported. Future research should investigate if adolescents with high levels of PA and CAI reduce their PA levels over time using longitudinal methods with larger sample sizes from both rural and urban settings.

Conclusion

To the best of our knowledge this was the first study conducted on adolescents to determine the prevalence of ankle injury history in rural western North Carolina as well as a history of ankle injury and reported PA levels. It is evident that the presence of CAI did not hinder this sample of adolescents from reporting high levels of PA, however, other research has shown that CAI has negative impacts on PA levels in adults. It can be concluded that PA may predispose adolescents to

ankle injury and subsequent chronic ankle instability. Further research is needed to determine the prevalence of ankle injury among adolescents and the relationship between adolescents with unstable ankles and CAI and their PA levels as they age.

Appendix A

International Physical Activity Questionnaire (IPAQ) Short form

1. During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, heavy construction, or climbing up stairs as part of work, school, and at home? Think about only those physical activities that you did for at least 10 minutes at a time.
2. How much time (minutes) did you usually spend on one of those days doing vigorous physical activities as part of your work?
3. Again, think about only those physical activities that you did for at least 10 minutes at a time at school, work, and home. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking
4. How much time (minutes) did you usually spend on one of those days doing moderate physical activities as part of your work?
5. During the last 7 days, on how many days did you walk for at least 10 minutes at a time?
6. How much time (minutes) did you usually spend on one of those days walking?
7. During the last 7 days, how much time (hours) did you usually spend sitting on a weekday?

Appendix B

Injury History

1. Dominate leg (which leg would you kick a ball with for maximum distance)?

Right

Left

Ambidextrous

2. Please describe any injuries you have had to your lower limb in the past 6 months

3. Have you had any fractures or surgeries in your legs? If so, explain:

Appendix C

Identification of Functional Ankle Instability (IdFAI)

Please carefully read the following statement:

“Giving way” is described as a temporary uncontrollable sensation of instability or rolling over of one’s ankle.

Please answer the following questions for your Right and Left ankles.

1. Approximately how many times have you sprained your ankle?

L: ____ R: ____

2. What was the last time you sprained your ankle?

L:

Never >2 years 1-2 years 6-12 months 1-6 months <1 month

R:

Never >2 years 1-2 years 6-12 months 1-6 months <1 month

3. If you have ever seen an athletic trainer, physical therapist, physician, or other healthcare provider, how did he/she characterize your most serious ankle sprain?

L:

Have not seen someone Mild (grade 1) Moderate (grade 2) Severe (grade 3)

R:

Have not seen someone Mild (grade 1) Moderate (grade 2) Severe (grade 3)

4. If you have ever used crutches, or other device, due to an ankle sprain how long did you use it?

L:

Never used a device 1-3 days 4-7 days 1-2 weeks 2-3 weeks >3 weeks

R:

Never used a device 1-3 days 4-7 days 1-2 weeks 2-3 weeks >3 weeks

5. What was the last time you experienced “giving way” in your ankle?

L:

Never >2 years 1-2 years 6-12 months 1-6 months <1 month

R:

Never >2 years 1-2 years 6-12 months 1-6 months <1 month

6. How often does the “giving way” sensation occur in your ankle?

L:

Never Once a year Once a month Once a week Once a day

R:

Never Once a year Once a month Once a week Once a day

7. Typically, when you start to roll-over (or ‘twist’) on your ankle can you stop it?

L:

Never rolled over Immediately Sometimes Unable to stop it

R:

Never rolled over Immediately Sometimes Unable to stop it

8. Following a typical incident of your ankle rolling over, how soon does it return to normal?

L:

Never rolled over Immediately <1day 1-2 days >2days

R:

Never rolled over Immediately <1day 1-2 days >2days

9. During “Activities of daily life”, how often does your ankle feel *UNSTABLE*?

L:

Never Once a year Once a month Once a week Once a day

R:

Never Once a year Once a month Once a week Once a day

10. During "Sport and/or recreational activities" how often does your ankle feel *UNSTABLE*?

L:

Never Once a year Once a month Once a week Once a day

R:

Never Once a year Once a month Once a week Once a day

Appendix D

Youth Outdoor Participation Survey

1. How much time did you spend outdoors on a typical weekday (Monday through Friday) this past week?

none ½ to 1 hr 2 – 3 hours
 less than ½ hour 1-2 hours more than 3 hours

2. Do you think you spend less, about the same or more time outdoors now than you did this time last year?

Less About the same More

- 2b. If in the question above you answered that you spend less time outdoors than a year ago, why do you think that is (**check all that apply**)?

Spent more time playing video games or TV

Spent more time on the internet, e-mailing, text messaging etc.

It is not safe to play or do sports outdoors

Was injured or had a health problem

Do not have friends or others to play or do outdoor sports with

There are no outdoor places to use, like sports fields, near my home or neighborhood

Do not have transportation

_____ Spent more time on school work or studying

_____ Other reason (Please specify: _____)

3. What was the main reason that you did not spend as much time outdoors?

4. What could be done to help you spend more time outdoors?

5. During this past week, what type of activities did you participate in? **Check all that apply.**

Attending camps, field trips, outdoor classes, or other organized outdoor events

Biking, jogging, walking, or other physically challenging activities

Bird watching, viewing wildlife, viewing wildflowers, or similar nature interests

Boating, jet skiing, water skiing, or other motorized water activities

Hiking, camping, fishing, or other nature activities

Playing with friends

Reading, studying, board games or other activities mostly done while sitting

Riding motorcycles, ATVs, snowmobiles, or other off-road motor vehicles

Snow skiing, snowboarding, cross-country skiing, snowshoeing, or other self-powered snow sports

Swimming, diving, snorkeling or other self-powered water activities

Team sports, such as soccer, baseball, field hockey, or football

Other sports such as tennis, golf, archery, yard games or any other sport activity

Other activities not listed.

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Vita

Brittany B. Holland was born in Jim Thorpe, Pennsylvania, to Mark and Alice Holland. She graduated from Jim Thorpe Area High School June 2011. That summer, she entered Pennsylvania State University to pursue a degree in Biochemistry and Molecular Biology. In August 2012, she decided to transfer universities to Immaculata University and continue the same path of Biology. However, in December 2013, she decided to change majors to Exercise Science. In May 2015, she graduated from Immaculata University and was awarded a Bachelor of Sciences degree. In fall of 2015, she accepted a graduate assistantship in Exercise Science at Appalachian State University and began to study toward a Master of Science degree. The M.S. was awarded in May 2017. Future endeavors for Miss. Holland is still up for debate.