



TOPICS IN EXERCISE SCIENCE AND KINESIOLOGY

Original Research

Incidence of Achilles Tendon Ruptures and Associated Factors in Women's Artistic Gymnastics

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ABSTRACT

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Achilles tendon rupture risk appears to be higher in women's artistic gymnastics compared to other collegiate sports, however little is understood about personal, training, and performance factors potentially associated with this elevated risk. Previous research has only examined gymnasts who have sustained Achilles tendon ruptures while in an NCAA environment. The overall incidence of Achilles tendon ruptures among gymnasts has not been assessed. This study aims to identify injury factors, Achilles rupture incidence and training habits related to Achilles tendon ruptures in current and former women's artistic gymnastics. A cross-sectional study design was performed using current and former competitive women's artistic gymnasts aged 18-40 years were recruited via snowball sampling to voluntarily complete an anonymous online survey. Information was collected about participant demographics, past Achilles injury, injury prevention strategies, and training habits. In this study, there was an increased incidence of reported Achilles tendon ruptures over the past fifteen years. Female competitive gymnasts were more likely to report an Achilles tendon rupture if they performed difficult skills, engaged in plyometric exercises 2-3 days/week, tumbled on the floor 2-3 days/week, and did not get their ankles taped consistently before activity. Most Achilles tendon ruptures happened during the competitive season, floor exercise, and the back tumbling punch. Clinicians working with gymnastics should consider implementing a way to monitor time spent performing difficult skills and plyometric exercise load to recognize gymnasts who may need prophylactic intervention or strategies to mitigate the risk of Achilles tendon rupture.

KEY WORDS: ATHLETICS, TENDON INJURY, GYMNASTICS TRAINING

INTRODUCTION

An Achilles tendon rupture is a severe injury that can potentially end an athlete's season and lead to long-term impairments in range of motion and strength. These ruptures are particularly prevalent in women's gymnastics, occurring four times more frequently than any other sport at

the collegiate level¹. The cause of an Achilles tendon rupture is most commonly due to an acute event which consists of forceful dorsiflexion upon contact with a surface¹⁻³. This type of mechanism is seen consistently on vault with the roundoff board punch or landing and on floor with back tumbling punch or landing. "Punch" consists of direct contact on a surface, such as a springboard or spring floor, with forceful dorsiflexion. Additionally, athletes with chronic inflammation and tissue degeneration due to microtears that form from overtraining are at higher risk³⁻⁵. Research has shown that intense repetitive training such as running, jumping, tumbling, and competing all four events in gymnastics regularly may increase risk for Achilles tendon rupture³⁻⁵. The treatment of choice for Achilles tendon ruptures is usually surgical repair, which can return up to 75-90 percent of function⁶. There are multiple methods of surgical repair of the Achilles tendon. Methods include drilling a hole in the calcaneus and securing the existing tendon to the new bone surface, directly accessing the ruptured tendon, then suturing the tendon back together. Alternatively using a tendon graft with a V-Y technique may be used⁷⁻⁹. Rehabilitation following surgery may take six months or longer¹⁰. Results from this study could lead to new sports medicine strategies and changes in training practices to aid in the prevention of Achilles tendon ruptures in women's artistic gymnastics.

Women's artistic gymnastics includes four events: vault, uneven parallel bars, balance beam, and floor. Competitions occur at three levels: Elite, Developmental Program, and collegiate. Elite gymnasts, divided into Junior Elite and Senior Elite categories, undergo rigorous year-round training, often exceeding 30 hours a week, and are expected to master numerous skills daily. Developmental Program levels usually consist of lower-level gymnasts with the aspiration of college sports. Difficulty in this level progressively increases, with Level 10 being the highest. In the Developmental Program athletes typically practice over 20 hours a week and are expected to perform numerous skills. Women's artistic gymnastics in the collegiate setting's skill difficulty is comparable to Developmental Program Level 10¹¹. In the collegiate setting, they are limited to a maximum of 20 hours of required team activities a week during the season and end up performing less repetitions per week than the other levels. While difficulty standards do rise every four years in sync with the summer Olympic games, it's crucial to highlight the repetition load requirements at each gymnastics level to factor in potential injury causes.

An online news article suggests that the incidence of Achilles tendon ruptures in women's National Collegiate Athletics Association (NCAA) gymnastics has been increasing over the past 6 years², but no peer-reviewed evidence explores this trend across all levels of women's artistic gymnastics. The most recent formal data collection on Achilles tendon ruptures and related factors was in October of 2021⁴. Previous studies have exclusively involved current women's collegiate gymnasts only, failing to account for or investigate any Achilles tendon ruptures that may have occurred at a Developmental Program or Elite training level. Additionally, existing research has not explored various factors related to Achilles tendon ruptures, such as leg dominance, event types, the difference between practice and competition settings or how any of these factors may be related to the total amount of Achilles tendon ruptures an individual has experienced. Moreover, there is a lack of investigation into gymnastics-specific factors like frequency of time on specific tumbling surfaces and plyometrics or ankle taping as a preventive

treatment. One study has found that there is a greater prevalence of Achilles tendon ruptures for gymnasts who perform "difficult" vault/floor skills⁴. Difficult skills in gymnastics can be defined as a skill that has been valued at a "D" or "E". Examples of these difficult skills are, but are not limited to, any double flipping tumbling passes, front tumbling passes with 1 ½ full twists or more, back tumbling passes with 2 ½ full twists or more, Yurchenko vaults with 1 full twist or more, and Tsukahara vaults with 1 full twist or more¹². This study aims to address these gaps in knowledge surrounding Achilles tendon ruptures in women's artistic gymnastics.

This study aims to identify injury factors, Achilles tendon rupture incidence and training habits related to Achilles tendon ruptures in current and former women's artistic gymnastics. It was hypothesized that (1) gymnasts who perform difficult skills on floor or vault, train/compete in floor or all around, perform plyometric exercises 2-3 days/week, and tumble on the hard floor >4 days a week would be at a greater risk of Achilles tendon rupture compared to gymnasts with other training habits; (2) gymnasts that do not participate in preventative exercises, and did not tape their ankles would be at greater risk of Achilles tendon rupture, when compared with gymnasts who do perform preventative exercises and tape their ankles consistently; and (3) there will be an increased incidence of Achilles tendon ruptures in the past 15 years in women's artistic gymnastics displayed.

METHODS

Participants

Current and former competitive women's artistic gymnasts aged 18-40 years were recruited to voluntarily complete an anonymous online survey (Qualtrics®). The survey was partially adapted from a previous study and was reviewed for content validity by an expert panel with gymnastics knowledge as well as survey-based research knowledge. The survey was piloted on a group of individuals⁴. Seventy collegiate women's artistic gymnastics programs were contacted via email through athletic trainers, coaches, athletic directors as well as social media postings. The recruitment email asked those who were contacted to forward the survey link to any of their current or past competitive gymnasts they had worked with. Participants were sent the link for the survey which was expected to take between five to fifteen minutes. Initial contact emails were sent out on May 30th, 2023 followed up by a reminder on July 7th, 2023. The last survey response was collected on July, 25th, 2023 and the survey was closed for new responses on July 26th, 2023. Previous research conducted on similar populations yielded response rates ranging from 9613 to 5814. Based on that data, the objective was to receive 300 survey responses with a final total of 432 respondents completing the survey^{4,12,13}.

Once the survey link was clicked by the participant, the survey remained open for seven days. IRB-informed consent was obtained from the participants and included as the first question in the survey. The inclusion criteria was comprised of current or former competitive artistic gymnasts between the ages of eighteen and forty. Exclusion criteria encompassed those who did not consent to the survey, listed their age outside of the accepted range, did not compete in artistic gymnastics, resided or competed outside of the United States, or reported an Achilles

tendon rupture occurring more than fifteen years ago. This study was approved by Southern Utah University's Institutional Review Board, followed procedures in accordance with the ethical standards of the Helsinki Declaration, and was in accordance with the ethical standards of the International Journal of Exercise Science¹⁴.

Protocol

A cross-sectional study design was performed using snowball sampling. The incentive to participate was that further research could potentially uncover trends or predisposing factors of Achilles tendon ruptures in women's artistic gymnastics. No compensation was offered for participation in this study. All participants digitally signed an informed consent statement. Potential risks included a potential for discomfort when answering questions about previous injuries; to mitigate this concern, participants were informed that they could skip any questions and end the survey at any time.

Information was collected about participant demographics, injury prevention strategies and training habits, and previously reported Achilles tendon rupture data. Participant demographics questions included: age, race, and reported number of previous Achilles tendon ruptures. Those who did not report rupturing their Achilles tendon only answered the question set addressing injury prevention strategies and training habit information (Appendix A).

Injury prevention strategies and training habit information questions included: events trained- if floor or all around were selected this question was followed with days/week on a hard tumbling surface; training/competing "difficult skills"; days/week plyometric exercises were implemented into workouts; consistent ankle taping (>3 days/week); and preventative treatments. If preventative treatments were selected this question was followed by what types of preventative treatments were performed (general ankle strengthening, ankle flexibility/mobility, and balance (Appendix A).

Questions varied slightly based on how many Achilles tendon ruptures the athlete had sustained. For each Achilles tendon rupture the individual reported, they were provided with an additional set of questions about specific injury data. This question set included: age when Achilles was ruptured, event performing during injury, what setting (practice, competition, other), years of competition before rupture, Developmental program level, year in college, or Elite level when injured, calendar year of injury, training period (preseason, season, offseason), dominant leg, if dominant leg Achilles tendon was ruptured, Achilles tendon pain prior to injury, how long they were experiencing symptoms before the rupture, and mechanism of injury (front tumbling punch, front tumbling landing, back tumbling punch, back tumbling landing, leaps/dance, or other). All responses were anonymous, and no identifying information was collected (Appendix A).

Statistical Analysis

Three different statistical analyses were used for the data collected from this study. Variability was calculated by Qualtrics® including count, minimum, maximum, mean, standard deviation,

and variance for quantitative data in addition to count and percentages for qualitative data. Comparisons between groups with and without a reported Achilles tendon rupture history were analyzed using a two-proportion z-test and 95% CIs (p values ≤ 0.05). Linear regression analysis was used to measure the strength of correlation between calendar years and ruptures.

RESULTS

Demographics

A total of 432 participants began the study, of which 77 were excluded due to the exclusion criteria described previously. Of 355 female competitive artistic gymnasts (age 24.5 ± 5.4 years) who met the inclusion criteria, 310 completed the entire survey (completion rate=87.3%). Some of the participants ($n=56$, 15.9%; 95% CI: 12.2%-20.1%) reported having sustained an Achilles tendon rupture that required surgical repair in the past 15 years (age 24.8 ± 5.2 years). Mean age of the gymnasts' first Achilles tendon rupture was 19.3 ± 2.1 years with mean 13.9 ± 3.6 years of competitive gymnastics experience before their injury. Participants' reported race was 82.25% White, 6.48% Black African American, 5.92% Asian, 1.41% Native American or Pacific Islander, 0.28% Alaskan Native, and 3.66% other.

Comparative data between groups (Table 1)

Compared with participants without ruptures, a significant difference ($p \leq 0.05$) was found between groups for the following activities: tumbling on the floor 2-3 days/week ($p=0.05$), tumbling on the floor 6-7 days/week ($p<0.01$), performing difficult skills ($p<0.01$), performing plyometric exercises 2-3 days/week ($p=0.02$), and not getting ankles taped consistently before activity ($p=0.04$).

There were no statistically significant differences between groups for the following activities: tumbling on the floor 0-1 days/week ($p=0.99$), tumbling on the floor 4-5 days/week ($p=0.08$), performing plyometric exercises 0-1 days/week ($p=0.11$), performing plyometric exercises 4-5 days/week ($p=0.26$), performing plyometric exercises 6-7 days/week ($p=0.88$), and participation in preventative treatment ($p=0.08$).

Participants from both groups were asked to indicate which events they trained in by selecting all that applied. Data from the group that did not report any Achilles tendon ruptures is as follows: Vault (14.61%), Bars (14.29%); Beam (14.77%); Floor (15.57%); All Around (40.77%). Data from the group that did report an Achilles tendon rupture is as follows: Vault (14.77%); Bars (13.64%); Beam (10.23%); Floor (21.59%); All Around (39.77%).

Question	Descriptor	No Achilles Rupture n(%)	Achilles Rupture n=52, n(%)	95% CI of Differences	P value
On average, how many days/week did you tumble on the hard floor?		Total number=258			
	0-1	15 (5.81)	3 (5.77)	-14.32, 15.12	0.99
	2-3	146 (56.59)	37 (71.15)	-28.28, -0.84	0.05
	4-5	92 (35.66)	12 (23.08)	-0.28, 25.44	0.08
	6-7	5 (1.94)	0 (0.0)	14.57, 24.23	0.0005
Did you train/compete "difficult" skills on vault or floor prior to injury?		Total number=277			
	Yes	209 (75.45)	51 (98.08)	-28.94, -16.26	0.0002
	No	68 (24.55)	1 (1.92)	16.32, 28.88	0.0002
How many days/week were plyometric exercises implemented into your workouts prior to injury?		Total number=267			
	0-1	50 (18.73)	5 (9.62)	-0.17, 18.39	0.112
	2-3	140 (52.43)	36 (69.23)	-30.70, -2.90	0.026
	4-5	71 (26.59)	10 (19.23)	-4.59, 19.31	0.265
	6-7	6 (2.25)	1 (1.92)	-3.80, 4.46	0.882
Did you get your ankles taped consistently? (>3 days/week)		Total Number=283			
	Yes	158 (55.83)	21 (40.38)	0.91, 29.99	0.040
	No	125 (44.17)	31 (59.62)	-29.99, -0.91	0.040

Table 1. Comparative data between Achilles tendon rupture and no Achilles tendon rupture groups. P-values ≤ 0.05 are considered significant and are indicated by boldface font.

Data collected about participants reporting Achilles tendon ruptures

Most participants who reported experiencing an Achilles tendon rupture mentioned only having one occurrence (82%), while 16% reported two Achilles tendon ruptures, and 2% reported three. The average age of participants when they first ruptured their Achilles tendon was 19.29 years; for the second rupture, it was 21 years, and for the third rupture it was 18 years. On average, participants had been involved in competitive gymnastics for 13.43 years before their first reported Achilles tendon rupture. The average number of years between the participants' first and second reported Achilles tendon ruptures was 2.88 years and between second and third reported Achilles tendon ruptures was 2 years.

The majority of ruptures (n=49, 86.0%) occurred during the floor exercise with 87.2% (n=37) of these occurring during a back tumbling punch. Most gymnasts had experienced Achilles tendon pain prior to their first rupture (60.5%); however, 77.8% of gymnasts had no prior Achilles tendon pain before their second rupture and 100% had no Achilles tendon pain prior to their third rupture. Most ruptures happened during the competitive season (n=40, 72.2%). For those who experienced one Achilles tendon rupture, the injury most commonly happened in-season (n=34, 76%), while for those with two Achilles tendon ruptures 56% (n=5) occurred in-season. For the participant who reported three Achilles tendon ruptures, the most common training period of injury was preseason (n=1, 100%). However, because there was only one participant that reported a third Achilles tendon rupture there is insignificant data to establish a pattern (Table 2).

Question	Descriptor	1st Achilles Rupture n(%)	2nd Achilles Rupture n=9, n(%)	3rd Achilles Rupture n=1, n(%)
On what event did you rupture your Achilles?		n=45		
	Vault	1(2.08)	0(0.0)	0(0.0)
	Bars	1(2.08)	1(11.11)	0(0.0)
	Beam	0(0.0)	1(11.11)	1(100.0)
	Floor	42(93.75)	4(44.44)	0(0.0)
	Other	1(2.08)	3(33.33)	0(0.0)
What setting did you rupture your Achilles in?		n=48		
	Competition	20(41.67)	4(44.44)	1(100.00)
	Practice	28(58.33)	2(22.22)	0(0.0)
	Other	0(0.0)	3(33.33)	0(0.0)
What Developmental Program level or Year in college did you rupture your Achilles tendon?		n=46		
	Level 8	1(2.17)	0(0.0)	0(0.0)
	Level 9	1(2.17)	0(0.0)	0(0.0)
	Level 10	11(23.91)	3(33.33)	1(100.0)
	Freshman	9(19.57)	0(0.0)	0(0.0)
	Sophomore	8(17.39)	1(11.11)	0(0.0)
	Junior	9(19.57)	0(0.0)	0(0.0)
	Senior	6(13.04)	1(11.11)	0(0.0)
	5th Year Senior	0(0.0)	3(33.33)	0(0.0)
	Other	1(2.17)	1(11.11)	0(0.0)
Did you rupture the achilles of your dominant leg?		n=45		
	Yes	14(31.11)	5(55.55)	0(0.0)
	No	31(68.89)	4(44.44)	1(100.0)
How long did you have Achilles tendon pain before your injury?		n=43		
	No pain	17(39.53)	7(77.77)	100.0
	<1 week	8(18.60)	0(0.0)	0(0.0)
	1 week- 1 month	7(16.28)	0(0.0)	0(0.0)
	2-3 months	5(11.63)	0(0.0)	0(0.0)
	>3 months	6(13.95)	3(33.33)	0(0.0)
How did you rupture your Achilles tendon?		n=36	n=7	n=0
	Front tumbling punch	0(0.0)	0(0.0)	0(0.0)
	Front tumbling landing	0(0.0)	0(0.0)	0(0.0)
	Back tumbling punch	32(94.44)	3(42.86)	0(0.0)
	Back tumbling landing	2(2.78)	1(14.29)	0(0.0)
	Leaps/Dance	0(0.0)	0(0.0)	0(0.0)
	Other	2(2.78)	3(42.86)	0(0.0)
What training period did you rupture your Achilles in?		n=45		
	Preseason	8(17.78)	1(11.11)	1(100.0)
	Season	34(75.76)	5(55.55)	0(0.0)
	Offseason	3(6.67)	3(33.33)	0(0.0)

Table 2. Comparative data between participant groups who have reported rupturing their Achilles tendon one, two, and three times. Participants filled out the same form multiple times depending on the number of ruptures reported.

The reported Achilles tendon rupture overall by competitive gymnastics level (Developmental Program level, college year, and Elite level) percentages listed from highest to lowest is as follows: Level 10 (n=15, 27%), Freshman (n=9, 16%), Sophomore (n=9, 16%), Junior (n=9, 16%), Senior (n=7, 13%), 5th year (n=4, 7%), other (n=2, 4%), Level 8 (n=1, 2%), Junior Elite (n=0, 0%), and Senior Elite (n=0, 0%).

There was a positive correlation between calendar years and the number of ruptures, meaning there has been an increase in reported Achilles tendon ruptures since 2008 ($R^2 = 0.68$, $p < 0.001$) (Figure 1). The data from each year broken down from 2008 through the first half of 2023 is reported with the format of "year (total # of reported Achilles tendon ruptures)": 2008(2); 2009(1); 2010(0); 2011(1); 2012(1); 2013(0); 2014(3); 2015(4); 2016(3); 2017(3); 2018(6); 2019(7); 2020(6); 2021(3); 2022(8); 2023(6).

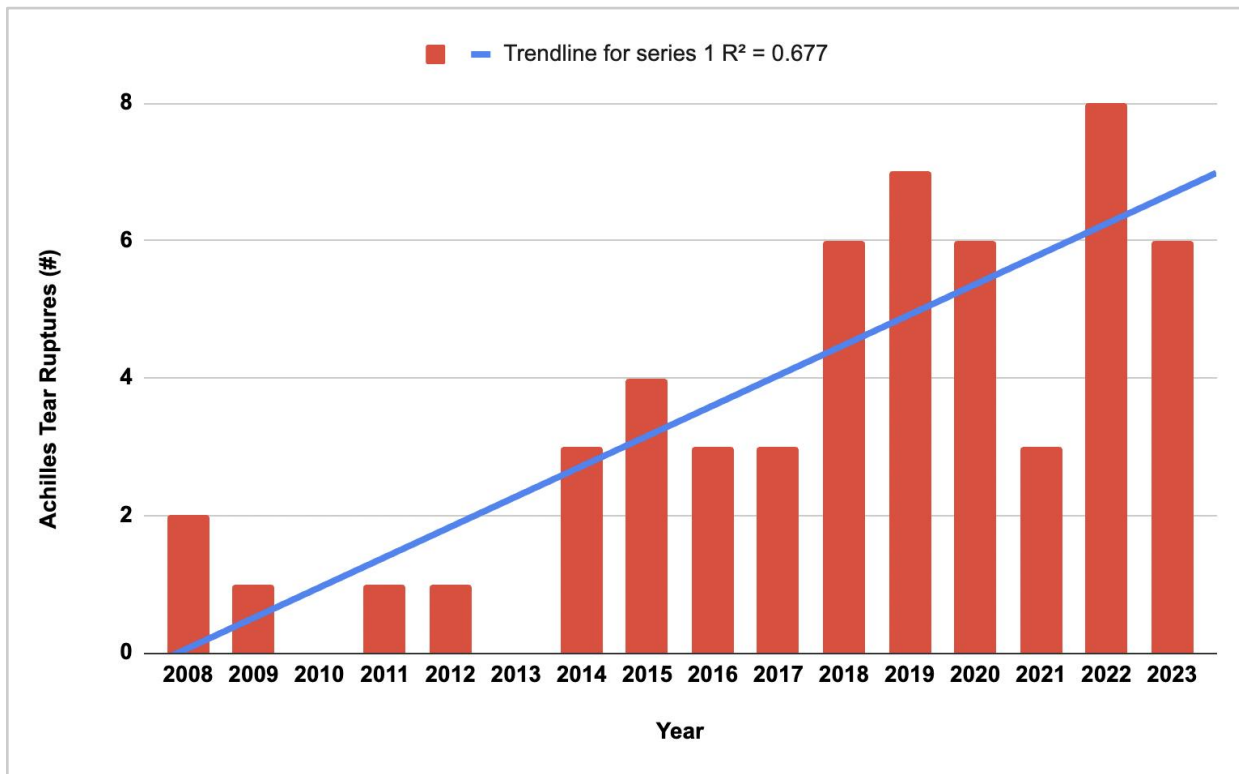


Figure 1. Linear regression analysis to measure the strength of correlation between calendar years and ruptures. $R^2=0.68$ which indicates a significant correlation. Data suggests that there is an increase in reported Achilles tendon ruptures in women's artistic gymnastics in the past fifteen years.

DISCUSSION

The proposed hypotheses were partially supported by the data collected in this study. The hypothesis was confirmed by the results showing that gymnasts who performed difficult skills on floor or vault, trained or competed in all around, performed plyometric exercises 2-3 days/week, or did not consistently tape their ankles had a higher incidence of Achilles tendon ruptures when compared to gymnasts with different training habits. Additionally, the hypothesis was confirmed by a positive correlation between calendar years and the number of ruptures, indicating that the incidence of reported Achilles tendon ruptures has risen over the past 15 years. However, the data did not support the hypothesis that gymnasts who tumble on the hard floor >4 days a week or do not participate in preventative exercises would have a higher incidence of Achilles tendon rupture compared to gymnasts with other training habits.

Previous research on Achilles tendon ruptures and associated factors in gymnastics have solely focused on those injuries in an NCAA environment. In this study, however, 29% of reported Achilles tendon ruptures were sustained before college suggesting that about a third of the data collected had not been explored prior to this study. Previous studies only inquired about

Achilles tendon ruptures during collegiate practice or competition. New findings from this research includes that female competitive gymnasts were more likely to report an Achilles tendon rupture if they were engaged in plyometric exercises 2-3 days/week, tumbled on the floor 2-3 days/week, and did not regularly get their ankles taped before activity. A higher percentage of participants in the Achilles tendon rupture group reported training the floor exercise compared to those without history of an Achilles tendon rupture. There was no significant data to support the idea that participating in preventative treatment exercises has an effect on the likelihood of the athlete rupturing their Achilles tendon, a topic that had not been researched prior to this study. The most common level that participants reported rupturing their Achilles tendon was Level 10, closely followed by freshman, sophomore, and junior years in college. According to the results from this study, gymnasts who have been competing for 12 years, are around 19 years old, and compete in gymnastics in Level 10, or freshman through junior year of college may face a greater risk of rupturing their Achilles for the first time.

This study examined the incidence of Achilles tendon ruptures among all women's artistic competitive gymnasts over the past 15 years, whereas an online news article focused only on NCAA injuries in the competition seasons between 2017-2022². In this study, there was an increased incidence of reported Achilles tendon ruptures in the past fifteen years, which confirms anecdotal evidence². Notably, 2021 was the only year with a significant drop in the number of reported Achilles tendon ruptures. This could be due to two reasons. First, 2021 was the first year/competition season following the outbreak of COVID-19, which caused many competitions in early 2021 to be canceled due to safety guidelines, reducing student-athlete exposures during the season. Second, in 2020, the pandemic required athletes at all settings to stay home during quarantine, leading to a forced cessation in training for weeks to months - an unusual break for artistic gymnasts during the off-season. This data suggests that due to the overuse etiology of Achilles tendon ruptures, enforced breaks of training in the off-season may reduce the likelihood of artistic gymnasts rupturing their Achilles tendon due to repetitive training.

In college gymnastics, off-season training isn't mandatory, however, it is often culturally expected. The findings from this study could encourage a shift in this expectation among coaches and athletes. In the Elite and Developmental Program competition settings, it is common to train through the off-season as well. According to the National Athletic Trainers' Association position statement on overuse injury in pediatrics, young athletes should participate in no more than 16-20 hours of training per week, have at least 1-2 days off per week, and should take a break of 2 to 3 non-consecutive months from a specific sport they play year-round¹⁵. This position statement also sets a pitch count for overhead athletes. Establishing a similar "punch" count for women's gymnastics could be a future intervention strategy across all levels. However, Elite and Developmental Program artistic gymnastics settings are not required to follow these position statement guidelines currently. Finding a way to implement these changes may be beneficial for the athletes' long-term health.

Female competitive gymnasts were more likely to report a history of Achilles tendon rupture if they performed difficult skills; most Achilles tendon ruptures happened during the competitive season, floor exercise, and the back tumbling punch which is consistent with previous findings^{4,5,16}. The back tumbling punch mimics the common mechanism of injury for Achilles tendon ruptures due to the forceful dorsiflexion upon impact.

The findings from this study can only be generalized to those working with or competing in women's artistic gymnastics in the past fifteen years. This data should not be generalized to males, those outside of the age range, or are involved with women's artistic gymnastics outside of the United States of America. A potential limitation exists in the demographics due to the majority of participants reporting their race as white. Due to this research being conducted via an online, voluntary, survey two methodological limitations exist; the true nature of the population cannot be determined and those with biases may have chosen to participate¹⁷.

This study does not cover all aspects related to Achilles tendon ruptures in women's artistic gymnastics. Future research should explore possible various factors such as equipment details (brand of floor, brand of tape, brand of mats, brand of sting mats, etc.), equipment age, optional equipment usage in training and competition (sting mats and four incher mats), differences between training and competition equipment, specific skill being performed at time of injury, weight training period, years competing level 10, day of the week, month of the year, taping habits (taping one ankle or both ankles, technique of ankle tape, how long tape had been applied prior to activity), the number of "punches" per day/week/season, athlete weight, amount of rest during off-season, and including men's gymnastics into research.

Female competitive gymnasts were more likely to report a history of Achilles tendon rupture if they performed difficult skills; most Achilles tendon ruptures happened during the competitive season, floor exercise, and the back tumbling punch which is consistent with previous findings^{4,5,16}. A greater risk of rupture during the back tumbling punch may be since the punch mimics the common mechanism of injury for Achilles tendon ruptures due to the forceful dorsiflexion upon impact. Clinicians working with competitive artistic gymnastics should consider monitoring the time their athletes spend training difficult skills and performing plyometric exercises. According to the results from this study, gymnasts with 12 years of experience, around 19 years old, and competing in gymnastics in Level 10, or in their freshman through junior years of college, might also be at a higher risk for rupturing their Achilles for the first time. It is also important to monitor athletes who train on the floor, perform back tumbling passes, or do not tape their ankles, as they may need preventative measures, strategies, or prophylactic intervention to reduce the risk of Achilles tendon rupture.

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Appendix A:

Incidence of Achilles Tendon Ruptures and Associated Factors in Women's Artistic Gymnastics

Start of Block: Consent

Incidence of Achilles Tendon Ruptures and Associated Factors in Women's Artistic Gymnastics- Informed Consent

You are invited to participate in a research study about the incidence of Achilles tendon ruptures in women's gymnastics. This study is being conducted by Kayla Horton as part of her Master of Athletic Training applied research project and Amanda Hawkes, her faculty supervisor.

In order to qualify to participate in this study you must be a current or former female competitive artistic gymnast and over the age of 18.

Purpose: The goal of this research study is to gather information related to Achilles tendon ruptures and identify predisposing factors that may be present in women's gymnastics.

Consent: Participation in this study is voluntary. You may discontinue the study at any time for any reason without penalty. You may ask questions at any time.

Confidentiality: All information collected from this survey will be kept anonymous. Participants' names, email addresses, home addresses, phone numbers, or IP addresses will NOT be collected.

Procedures: If you agree to participate in this study, you will be answering questions via an online survey about your personal demographics, gymnastics injury information, and training habits.

Duration: This survey is expected to take you 5-15 minutes.

Risks: Answering some of the questions about previous injury may be upsetting, but we expect that this will not be different from the kinds of things you discuss with those close to you. You may skip any questions you don't want to answer and you may end the survey at any time.

Benefits: There are no direct benefits to participation in this study.

Compensation: No compensation will be given as a result of completing this survey.

The Institutional Review Board (IRB) of Southern Utah University has reviewed this study for the protection of the rights of human subjects in research studies, in accordance with federal

and state regulations. By completing this survey, you are consenting to participate in this study. *Please print or save a copy of this form for your records. *

Do you understand the above information and consent to continue the survey?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Consent

Start of Block: Demographics

What is your current age?

18 27 37 46 56 65

Move Slider to Age ()	
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What is your race?

- ☐ Alaskan Native or American Indian (1)
- ☐ Asian (2)
- ☐ Black or African American (3)
- ☐ Native Hawaiian or Other Pacific Islander (4)
- ☐ White (5)
- ☐ Other (6) _____

Have you suffered an Achilles tendon rupture that required surgical repair during gymnastics activity in the last 15 years?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Demographics

Start of Block: Block 9

How many times have you ruptured your Achilles tendon? (You will be prompted to fill out responses for each injury individually)

End of Block: Block 9

Start of Block: Injury data

Achilles tendon rupture #1

What age did you rupture your Achilles tendon?

10 14 18 22 26 30

Move Slider to Age ()

On what event did you injure your Achilles?

☐ Vault (1)

☐ Bars (2)

☐ Beam (3)

☐ Floor (4)

☐ Other (5) _____

What setting did you rupture your Achilles in?

☐ Competition (1)

☐ Practice (2)

☐ Other (3) _____

How many years did you participate in competitive gymnastics before your injury?

0 2 4 6 8 10 12 14 16 18 20

Click to write Choice 1 ()

What Junior Olympic level/ Year in college/ Elite training level did you rupture your Achilles tendon?

☐ Level 6 (1)

☐ Level 7 (2)

☐ Level 8 (3)

☐ Level 9 (4)

☐ Level 10 (5)

☐ Freshman (6)

☐ Sophomore (7)

☐ Junior (8)

☐ Senior (9)

☐ 5th Year Senior (10)

☐ 6th Year Senior (11)

- ☐ Junior Elite (12)
- ☐ Senior Elite (13)
- ☐ Other (14) _____

What year did you rupture your Achilles?

2008 2012 2016 2019 2023

Move slider to year ()	
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What training period did you rupture your Achilles tendon?

- ☐ Preseason (1)
- ☐ Season (2)
- ☐ Off Season (3)

What is your dominant leg? (which leg leads in your hurdle, start a cartwheel, etc.)

- ☐ Right (1)
- ☐ Left (2)

Did you rupture the Achilles tendon of your dominant leg?

- ☐ Yes (1)
- ☐ No (2)

Did you have Achilles tendon pain prior to your Achilles tendon rupture?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Injury data

Start of Block: Tendonopathy timeline

How long did you experience Achilles tendon pain prior to your injury?

- ☐ <1 week (1)
- ☐ 1 week-1 month (2)
- ☐ 1-3 months (3)
- ☐ >3 months (4)

End of Block: Tendonopathy timeline

Start of Block: Tumbling

How did you rupture your Achilles?

- ☐ Front tumbling punch (1)
- ☐ Front tumbling landing (2)
- ☐ Back tumbling punch (3)
- ☐ Back tumbling landing (4)
- ☐ Leaps/Dance (5)
- ☐ Other (6) _____

End of Block: Tumbling

Start of Block: Injury data #2

Achilles tendon rupture #2

What age did you rupture your Achilles tendon?

10 14 18 22 26 30

Move Slider to Age ()	
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On what event did you injure your Achilles?

- ☐ Vault (1)
- ☐ Bars (2)
- ☐ Beam (3)
- ☐ Floor (4)
- ☐ Other (5) _____

What setting did you rupture your Achilles in?

- ☐ Competition (1)
- ☐ Practice (2)
- ☐ Other (3) _____

How many years did you participate in competitive gymnastics before your injury?

0 2 4 6 8 10 12 14 16 18 20

Click to write Choice 1 ()	
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What Junior Olympic level/ Year in college/ Elite training level did you rupture your Achilles tendon?

- ☐ Level 6 (1)
- ☐ Level 7 (2)
- ☐ Level 8 (3)
- ☐ Level 9 (4)
- ☐ Level 10 (5)
- ☐ Freshman (6)
- ☐ Sophomore (7)
- ☐ Junior (8)
- ☐ Senior (9)
- ☐ 5th Year Senior (10)
- ☐ 6th Year Senior (11)
- ☐ Junior Elite (12)
- ☐ Senior Elite (13)
- ☐ Other (14) _____

What year did you rupture your Achilles?

2008 2012 2016 2019 2023

Move slider to year ()	
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What training period did you rupture your Achilles tendon?

- ☐ Preseason (1)
- ☐ Season (2)
- ☐ Off Season (3)

What is your dominant leg? (which leg leads in your hurdle, start a cartwheel, etc.)

- ☐ Right (1)
- ☐ Left (2)

Did you rupture the Achilles tendon of your dominant leg?

- ☐ Yes (1)
- ☐ No (2)

Did you have Achilles tendon pain prior to your Achilles tendon rupture?

☐ Yes (1)

☐ No (2)

End of Block: Injury data #2

Start of Block: Injury data #3

Achilles tendon rupture #3

What age did you rupture your Achilles tendon?

10 14 18 22 26 30

Move Slider to Age ()

On what event did you injure your Achilles?

☐ Vault (1)

☐ Bars (2)

☐ Beam (3)

☐ Floor (4)

☐ Other (5) _____

What setting did you rupture your Achilles in?

☐ Competition (1)

☐ Practice (2)

☐ Other (3) _____

How many years did you participate in competitive gymnastics before your injury?

0 2 4 6 8 10 12 14 16 18 20

Click to write Choice 1 ()

What Junior Olympic level/ Year in college/ Elite training level did you rupture your Achilles tendon?

☐ Level 6 (1)

☐ Level 7 (2)

☐ Level 8 (3)

- ☐ Level 9 (4)
- ☐ Level 10 (5)
- ☐ Freshman (6)
- ☐ Sophomore (7)
- ☐ Junior (8)
- ☐ Senior (9)
- ☐ 5th Year Senior (10)
- ☐ 6th Year Senior (11)
- ☐ Junior Elite (12)
- ☐ Senior Elite (13)
- ☐ Other (14) _____

What year did you rupture your Achilles?

2008 2012 2016 2019 2023

Move slider to year ()	
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What training period did you rupture your Achilles tendon?

- ☐ Preseason (1)
- ☐ Season (2)
- ☐ Off Season (3)

What is your dominant leg? (which leg leads in your hurdle, start a cartwheel, etc.)

- ☐ Right (1)
- ☐ Left (2)

Did you rupture the Achilles tendon of your dominant leg?

- ☐ Yes (1)
- ☐ No (2)

Did you have Achilles tendon pain prior to your Achilles tendon rupture?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Injury data #3

Start of Block: Injury data #4

Achilles tendon rupture #4

What age did you rupture your Achilles tendon?

10 14 18 22 26 30

Move Slider to Age ()

On what event did you injure your Achilles?

- ☐ Vault (1)
- ☐ Bars (2)
- ☐ Beam (3)
- ☐ Floor (4)
- ☐ Other (5) _____

What setting did you rupture your Achilles in?

- ☐ Competition (1)
- ☐ Practice (2)
- ☐ Other (3) _____

How many years did you participate in competitive gymnastics before your injury?

0 2 4 6 8 10 12 14 16 18 20

Click to write Choice 1 ()

What Junior Olympic level/ Year in college/ Elite training level did you rupture your Achilles tendon?

- ☐ Level 6 (1)
- ☐ Level 7 (2)
- ☐ Level 8 (3)
- ☐ Level 9 (4)
- ☐ Level 10 (5)
- ☐ Freshman (6)
- ☐ Sophomore (7)
- ☐ Junior (8)
- ☐ Senior (9)
- ☐ 5th Year Senior (10)
- ☐ 6th Year Senior (11)

- ☐ Junior Elite (12)
- ☐ Senior Elite (13)
- ☐ Other (14) _____

What year did you rupture your Achilles?

2008 2012 2016 2019 2023

Move slider to year ()	
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What training period did you rupture your Achilles tendon?

- ☐ Preseason (1)
- ☐ Season (2)
- ☐ Off Season (3)

What is your dominant leg? (lead leg in your hurdle, leg you start a cartwheel with, etc.)

- ☐ Right (1)
- ☐ Left (2)

Did you rupture the Achilles tendon of your dominant leg?

- ☐ Yes (1)
- ☐ No (2)

Did you have Achilles tendon pain prior to your Achilles tendon rupture?

- ☐ Yes (1)
- ☐ No (2)

End of Block: Injury data #4

Start of Block: Preinjury/ Training habits

Training Habits

What events did you train prior to injury? (Select all that apply)

- ☐ Vault (1)
- ☐ Bars (2)
- ☐ Beam (3)
- ☐ Floor (4)
- ☐ All Around (5)

Did you get your ankles taped consistently prior to injury? (>3 days/week)

- ☐ Yes (1)
- ☐ No (2)

Did you train/compete "difficult" skills on vault or floor prior to injury? This includes D or E level skills (Double-tuck, double-pike, double-layout, back 2 1/2 twist, front 1 1/2, yurchenko 1/1, yurchenko 1 1/2, etc.)

- ☐ Yes (1)
- ☐ No (2)

How many days/week were plyometric exercises implemented into your workouts prior to injury? (consecutive jumps, box jumps/depth jumps, etc.)

- ☐ 0-1 (1)
- ☐ 2-3 (2)
- ☐ 4-5 (3)
- ☐ 6-7 (4)

Did you participate in any preventative treatment for Achilles injury prior to your tendon rupture?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Unsure (3)

End of Block: Preinjury/ Training habits

Start of Block: Preventative treatment

What types of preventative treatments did you perform? (Select all that apply)

- ☐ General Ankle Strengthening (1)
- ☐ Ankle flexibility/mobility (2)
- ☐ Balance exercises (3)
- ☐ Other (4) _____

End of Block: Preventative treatment

Start of Block: Hard floor tumbling

On average, how many days/week did you tumble on the hard floor?

- ☐ 0-1 (1)

- o 2-3 (2)
- o 4-5 (3)
- o 6-7 (4)

End of Block: Hard floor tumbling

Start of Block: Preinjury (Healthy group)

Training habits

What events have you trained? (Select all that apply)

- ☐ Vault (1)
- ☐ Bars (2)
- ☐ Beam (3)
- ☐ Floor (4)
- ☐ All Around (5)

Did you get your ankles taped consistently? (>3 days/week)

- o Yes (1)
- o No (2)

Did you train/compete "difficult" skills on vault or floor? This includes D or E level skills (Double-tuck, double-pike, double-layout, back 2 1/2 twist, front 1 1/2, yurchenko 1/1, yurchenko 1 1/2, etc.)

- o Yes (1)
- o No (2)

How many days/week are plyometric exercises implemented into your workouts? (consecutive jumps, box jumps/depth jumps, etc.)

- o 0-1 (1)
- o 2-3 (2)
- o 4-5 (3)
- o 6-7 (4)

Have you participated in any preventative treatment for Achilles tendon injuries?

- o Yes (1)
- o No (2)
- o Unsure (3)

End of Block: Preinjury (Healthy group)