Undergraduate Honors Thesis

Perceptions regarding finger injuries and safe training practices in elite, adolescent rock climbers

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Key Term Definitions

Key Term	Definition
A2 pulley rupture	Tearing the second annular ligament of the finger and bowstringing of the underlying flexor tendons
Bouldering	Discipline of climbing without ropes on short walls with pads below for protection
Campus board	Training tool made of wooden rungs oriented vertically in series and slightly overhanging designed for pull up-like exercises
Crimp grip	Flexion of the proximal interphalangeal (PIP) joint and extension of the distal interphalngeal (DIP) joint to grasp a small edge while relying on the fingertips
Double dyno	Jumping to a hold with two hands simultaneously. On a campus board, the move is performed unaided by the lower limbs, which hang free from the board
Epiphyseal fracture	A fracture that involves the growth plate, also known as a growth plate injury
Growth plate	The area of growing tissue near the ends of long bones (between the metaphysis and epiphyses). The growth plate is also known as the physis
Salter-Harris III fracture	A pediatric-specific fracture extending through the physis (growth plate), and to the articular surface
Sloper grip	Extension of the proximal interphalngeal (PIP) joint, flexion of the distal interphalngeal (DIP) joint to grasp a smooth sloping hold with little positive surface
Speed climbing	Discipline where climbers race side-by-side on a wall of uniform height (15m), length, hold design, and orientation
Sport climbing	Discipline of climbing with ropes. Two subcategories exist: top-rope and lead climbing
Stress fracture	Fracture of a bone caused by repetitive mechanical stress

Abstract

Background: With the inclusion of climbing in the 2020 Olympics, the number of adolescent competitors is on the rise. Epiphyseal fractures to the middle phalanx, also known as growth plate injuries, are almost exclusive to adolescent climbers, and the most common climbing injury in adolescent competitors. A2 pulley ruptures are the most common injury in skeletally mature climbers. There is a paucity of research on youth-specific climbing injuries and no previous research on perceptions of adolescent rock climbers about youth-specific climbing injuries.

Purpose: To examine the awareness, perceptions, and training practices of youth-specific climbing injuries and risk factors amongst elite, adolescent rock climbers.

Methods: We surveyed elite adolescent rock climbers, ages 8-18, competing in the 2017 USA Climbing Sport and Speed National Championships. Subjects answered questions on their knowledge and awareness of the most common youth climbing injury and safe training practices. Chi Square, one-way ANOVAs, and Bonferroni post hoc tests identified misperceptions about youth climbing injuries and the safe age to start double dyno campusing, a climbing-specific training exercise. Risk ratios were used to make accuracy comparisons between adolescent competitors who self-reported as injury "informed" and "uninformed." A Fisher's Exact test was used to determine if training regularly on the International Federation of Sport Climbing (IFSC) speed wall correlated with self-reported growth plate injuries.

Results: 267 climbers completed the survey (mean age =13.99±2.66 SD, 51.9% male, 48.1% female). The adult-specific A2 pulley injury was erroneously reported by the subjects to be the most common youth climbing injury, with an average

ranking of 3.09±2.20 SD 95% confidence interval (CI) on a scale of 1 (most common) to 8 (least common). Growth plate injury to the finger ranked second most common, with an average ranking of 4.0±2.22. These rankings were significantly different ($p<0.0001$). Only 5.7% of climbers correctly reported the safe age to start double dyno campus board training, a risk factor for growth plate injuries. 48.9% of climbers reported they were aware of growth plate injuries to the finger; yet only 52.8% of these climbers correctly identified the injuries as stress fractures. 73.5% overall reported growth plate finger injuries to either be a type of A2 pulley injury or did not know. Growth plate injuries were significantly more common among adolescent climbers who trained regularly on the IFSC speed wall ($p=0.02$).

Conclusion:

Adolescent climbers are prone to characterizing skeletally immature climbing-specific injuries as A2 pulley injuries seen in skeletally mature climbers. Training regularly on the IFSC speed wall appears to be an additional risk factor for growth plate injuries. As climbing enters the 2020 Olympics, addressing misperceptions will help athletes, parents, and coaches understand the risk for growth plate injuries and guide adolescent climbers and parents to seek medical attention when appropriate. Educating youth, coaches, and parents about finger injuries may reduce the incidence of growth plate injuries and the potential for permanent finger deformity and loss of function.

Key words: rock climbing, epiphyseal fracture, growth plate injury, misperceptions

Introduction:

Competition climbing is one of the fastest growing youth sports in the United States. In 2012, roughly 1.5 million youth between the ages of six and seventeen participated in bouldering or sport climbing in the United States (Outdoor Foundation, 2013). On August 3, 2016, the International Olympic Committee (IOC) approved climbing to be an official sport in the 2020 Olympic Games, which should increase the sport's popularity further. Meanwhile, competitive gym climbing in the United States is a relatively new sport, as the first United States Junior National Championships was organized in 1994 (CBJ, 2014). Competition climbing is associated with injuries that are almost exclusive to climbing, and commonly misunderstood in youth. Similar to gymnastics, competitive climbers often reach elite levels at a young age, prior to skeletal maturation, and podium athletes in the United States and European adult competition circuits have been as young as sixteen (Watts, 2004). Consequently, climbing-specific injuries, particularly in youth, are occurring at rates that appear to be outpacing education and awareness about these injuries.

Many youth athletes are involved in early sport specialization in order to obtain elite status, which is competing in only one sport year-round at a young age. Early specialization has been increasing in frequency (Mostafavifar, 2013) and can lead to overuse injuries, as 50% of injuries seen in pediatric sports medicine clinics are overuse in nature (Callender, 2010). During peak height velocity, adolescents are more prone to muscle imbalances and rapid growth occurs at the physes, making the athletes more vulnerable to overuse injury in these areas (Callender,

2010). Consequently, the American Academy of Pediatrics Committee on Sports Medicine recommends against sport specialization before the age of twelve or thirteen.

There is a paucity of literature regarding early sport specialization specifically in climbing. Year-round specialization in bouldering places youth climbers at high risk for epiphyseal fractures, in addition to finger-tendon injury, elbow tendonitis, and shoulder injuries (Horst, 2015). Injury rates are reduced by sport diversification or alternating between bouldering and sport climbing, as sport climbing generally involves movements that are less powerful and dynamic than bouldering (Horst, 2015).

As the number of adolescent competitors increases, improving injury knowledge and awareness could help reduce injury rates. Recreational climbers have a 75-90% probability of developing an upper limb or overuse injury (Wright, 2001; Rooks, 1995) and an even greater likelihood exists for elite, competitive climbers. An estimated 50% of elite sport climbers obtain an injury at the proximal interphalngeal joint (PIP) (Rooks, 1997). In adolescent climbers specifically (ages 11-19), an estimated 42% of injuries are overuse and 21% involve the hands and fingers (Woollings et al., 2015).

Epiphyseal fractures to the middle phalanx, also known as growth plate injuries, or stress fractures, are the most common pediatric climbing injury and most often occur around pubescent age (Bayer et al., 2013; Hochholzer et al., 2005; Morrison et al., 2007). Unlike adults, adolescent growth plates are two to five times weaker than the surrounding connective tissue (Caine et al., 2006 & Maffulli et al.,

2000). There have been almost one hundred reported cases of epiphyseal fractures in adolescent climbers in the literature since 1997, when they were first reported among five teenage climbers (mean age, 13.6 years) (El-Sheikh et al., 2017; Schoffl et al., 2004). Epiphyseal fractures appear to have increased 600% just in the past decade (Horst, 2017). The majority of epiphyseal fractures in youth climbers are fatigue fractures caused by repetitive stress or microtraumas (Hoccholzer and Schoffl, 2005). Eighty-one percent have been reported as Salter-Harris type III injuries (Hoccholzer and Schoffl, 2005), which are characterized as a fracture extending through the physis and epiphysis with continuation to the articular surface.

Epiphyseal fractures in adolescent climbers tend to be overuse in nature, but are often ignored until the pain acutely increases in severity. Hochholzer et al. (2005) reported that all patients with epiphyseal fractures (ages 13-16) reported a slow onset of pain in the middle phalanx, in addition to swelling on the dorsal side of the proximal interphalangeal joints (PIP) and some complained of reduced range of motion. Injuries to the physis may result in growth arrest, long term pathological changes, and permanently decreased range of motion, especially among those who delay reporting joint pain, ignore medical advice, or continue to train intensively on the campus board (Morrison et al., 2007). Finger injuries in elite youth climbers are also likely to go unreported, especially among those who climb grades identical to elite, skeletally mature climbers (Morrison et al., 2007). Schoffl et al. (1998) also found that 28% of climbers who have climbed for at least fifteen years showed osteoarthritic findings on radiographs, but only a few of them reported finger pain.

The A2 pulley is the most common climbing injury in skeletally mature athletes, but is rare in youth (Schlegel et al., 2002). Rohrbough et al. (2000) reported climbers suffering from A2 pulley pain were significantly older than those who were not (mean age 30.7 vs. 22.6, respectively, p=0.004). In addition, the A2 pulley injury has been researched slightly more than ten years prior to when epiphyseal fractures in adolescent climbers were first reported in 1997 (Rohrbough et al., 2000). Unlike epiphyseal fractures, A2 pulley ruptures often have a "popping" sound that is distinct to this injury (Rohrbough et al., 2000). The A2 pulley rupture is found in up to 26% of climbers and in some instances, bowstringing of the underlying flexor tendon may occur (Young, 2002; Bollen & Gunson, 1990; Rohrbough et al., 2000) which decreases range of motion (Moutet, 2003). Simultaneous flexion of the PIP joint and extension of the DIP joint, also known as the crimp grip, is most associated with this injury. The force applied to the A2 pulley in this position is 36 times higher than during extension of the PIP joint and flexion of the DIP joint, also known as the sloper grip (Vigouroux et al., 2006).

Adolescent rock climbers have many risk factors associated with epiphyseal fractures. Amongst junior competition climbers studied, two-thirds who trained regularly on the campus board developed epiphyseal fractures and most were of pubescent age (Morrison et al., 2007). The campus board is a training tool made of narrow wooden holds in series on an 8-10 foot overhanging board, which climbers use for pull up-like exercises. Particularly, "jumping" to a wooden rung on the campus board with two hands simultaneously and without the use of feet (double dyno campus board training), is known to be high risk for injury. According to the

British Mountain Council, adolescent climbers younger than eighteen years of age should avoid double dyno campus board training, which can damage the physis. Another risk factor is the crimp grip, particularly while bouldering, which puts a large amount of stress on the PIP joints (Schoffl, 2003). Adolescent climbers should also avoid hypergravity isolation training, as the use of additional weights is another risk factor for epiphyseal fractures (Horst, 2015).

In one study, 8.3% of climbers who delayed reporting joint pain, ignored medical advice, and continued to train intensively, especially on the campus board, experienced permanent deformity of the affected finger and diminished range of motion (Morrison et al., 2007). Due to the risk for epiphyseal fractures, the UIAA medical commission proposed and the IFSC accepted a sixteen-year minimum age for participation in adult international bouldering competitions (Schoffl, 2000).

The International Federation of Sport Climbing (IFSC) speed wall was first introduced in 2007 and in 2010, the United States received its first official IFSC speed wall (CBJ, 2014). On the IFSC speed wall, climbing hold shape, distance between holds, wall height (15m) and angle, and specific timers make the wall uniform for every competitor and country. Unlike past international climbing competitions, each athlete will have to compete in a combined scoring format of each discipline (Bouldering, Sport, and Speed Climbing) at the 2020 Olympic Games. Unlike bouldering and sport climbing, speed climbing is practiced almost solely by youth climbers (CBJ, 2014). Although currently unrecognized as a risk factor for epiphyseal fractures, training regularly on the IFSC speed wall involves repetitive dynamic movements that are similar to double dyno campus board training.

The aim of our study was to examine the awareness and knowledge of youth-specific climbing injuries and risk factors amongst elite, adolescent rock climbers. Our hypotheses were that 1) the majority of elite, adolescent rock climbers mistakenly believe the most common pediatric climbing injury is the A2 pulley 2) the majority of elite, adolescent rock climbers are misinformed about safe training techniques in the skeletally immature athlete and 3) training regularly on the International Federation of Sport Climbing (IFSC) speed wall is a risk factor for self-reported epiphyseal fractures.

Methods:

Participants:

We surveyed elite adolescent rock climbers, ages 8-18, competing in the 2017 USA Climbing Sport and Speed National Championships during athlete registration. The study was approved by the University of Colorado Boulder Institutional Review Board and the athletes and parents provided written informed assent and consent, respectively. Inclusion criteria were adolescent climbers, between the ages of 8-18 years old, and who were competing in the 2017 USA Climbing SCS (Sport and Speed) National Championships. Exclusion criteria were competitors younger than age eight, older than age eighteen, or who were not competing in the National Championships.

Study Design:

Subjects answered survey questions on their knowledge and awareness of the most common youth climbing injury and safe training practices.

Statistical Analysis:

Chi Square, one-way ANOVAs, and Bonferroni post hoc tests identified misperceptions about youth climbing injuries and the safe age to start double dyno campus board training. Risk ratios were used to compare the percentage of athletes who correctly understood youth climbing injuries between those who self-reported as "informed" and "uninformed" when surveyed about injuries. The Fishers Exact test was used to examine if training regularly on the IFSC speed wall is an additional risk factor for growth plate injuries. Means of quantitative variables are reported with standard deviations (SD). Confidence intervals (CI) for percentages are 95% and use the Clopper-Pearson method (Clopper and Pearson, 1934).

Results:

Education and Awareness

Self-Reported Injuries:

Two hundred and sixty-seven athletes completed the survey (mean age =13.99±2.66 SD, 51.9% male, 48.1% female). When asked what injuries an athlete had obtained from climbing, 41.8% of athletes self-reported never obtaining an injury, 14.9% self-reported obtaining a pulley injury, and only 4.6% reported obtaining a growth plate injury to the finger, the second least common answer (*Table 1*).

Table 1. *Percentage of self-reported injuries by type*

Self-Reported Injuries by Type	***Frequency (%)***
None	41.8%
Other	19.9%
Ankle Sprain	16.1%
Pulley Injury	14.9%
Back/Posture Pain	13.4%
Tendon Injury to Wrist	10.9%
Elbow Tendonitis	10.0%
Rotator Cuff/Labrum injury of shoulder	9.2%
Growth plate injury to finger	**4.6%**
Meniscus tear of knee	1.1%

Ranking of Youth-Specific Climbing Injuries:

The adult-specific A2 pulley injury was erroneously reported to be the most common youth climbing injury, with an average ranking of 3.09±2.20 on a scale of 1 (most common) to 8 (least common) (*Figure 1a)*. The youth-specific and most common injury in adolescent climbers, growth plate injury to the finger, ranked second most common, with an average ranking of 4.0±2.22. These rankings were significantly different ($p<0.0001$). We further separated the athletes as self-reported informed or uninformed about growth plate injuries (GPI) that ranked each injury as most common (*Figure 1b*). Slightly more than 35% of athletes overall ranked A2 pulley injury as the most common youth climbing injury (*Figure 1c*). We further separated the athletes as self-reported informed or uninformed about growth plate injuries and then ranked the injuries by the percent of youth athletes that ranked each injury as most common (*Figure 1d*).

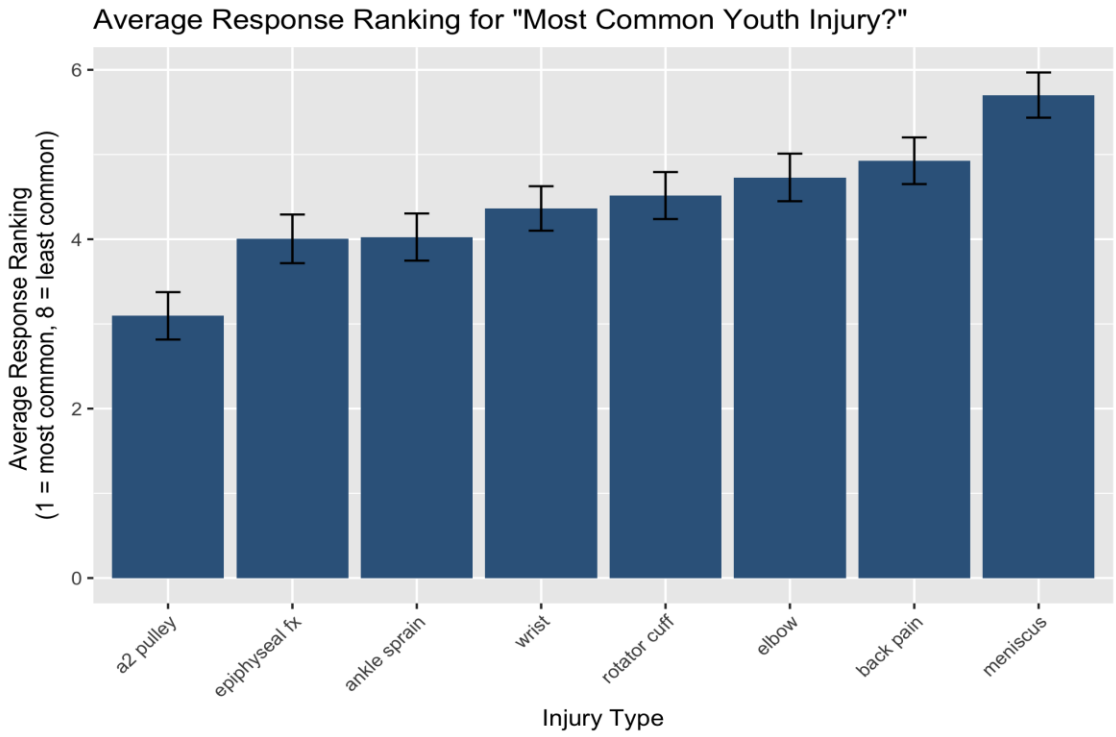

Figure 1a. *Average response ranking when asked to rank most common youth climbing injury (error bars = 95% CI, p<0.0001).*

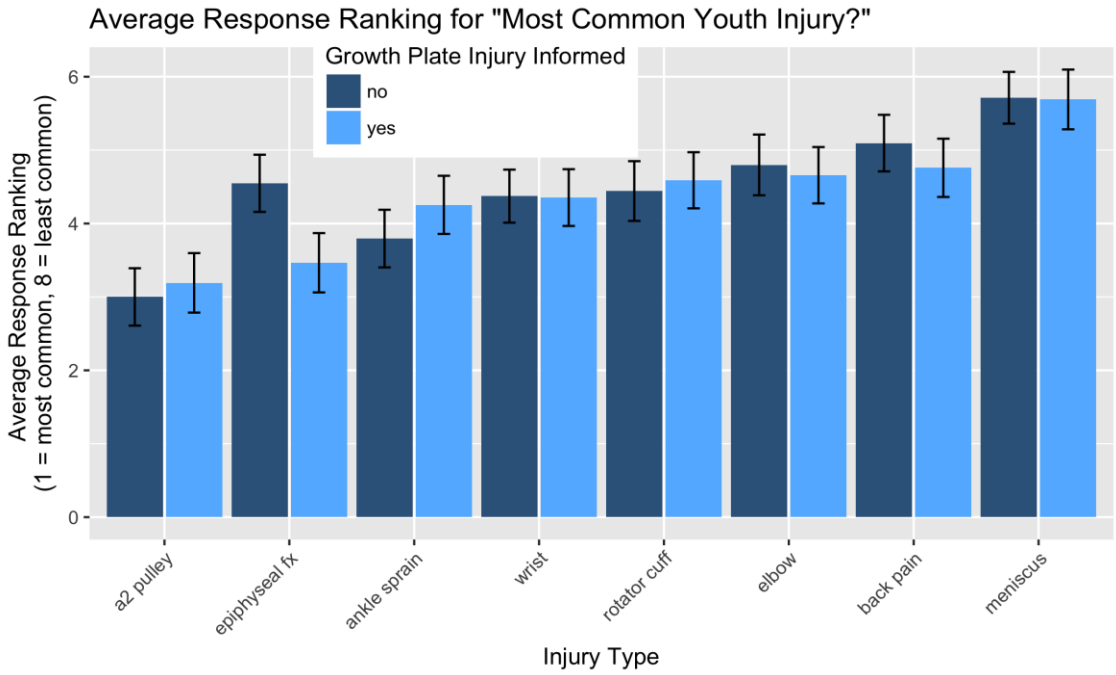

Figure 1b. *Average response ranking when asked to rank most common youth climbing injury between GPI informed and GPI uninformed (error bars = 95% CI, p<0.0001).*

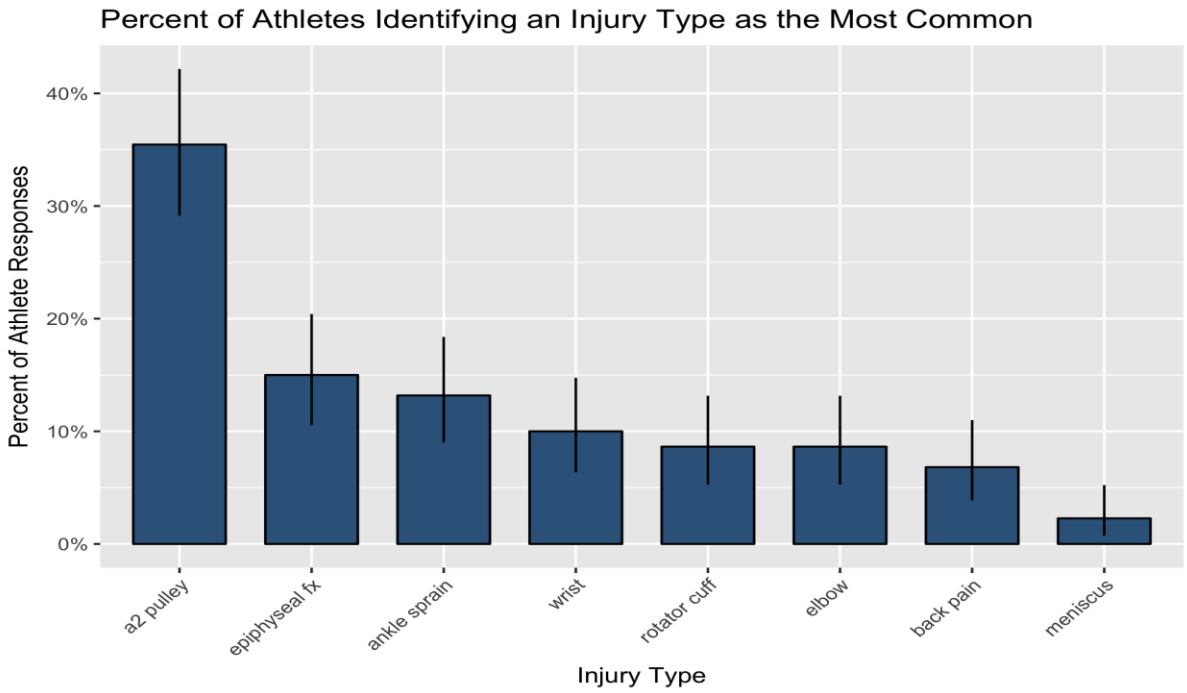

Figure 1c. *Percent of responses that ranked a given youth injury as most common (error bars = 95% CI, p<0.0001).*

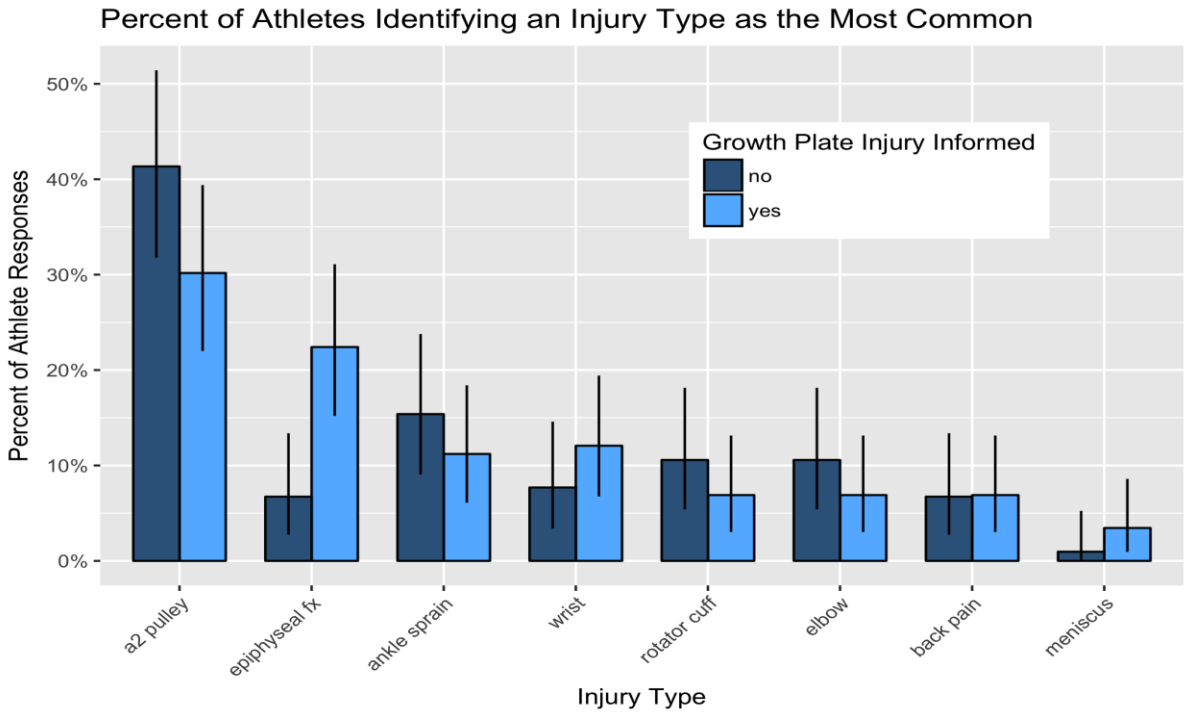

Figure 1d. *Percent of responses that ranked a given youth injury as most common between GPI informed and GPI uninformed (error bars = 95% CI, p<0.0001).*

Awareness of growth plate injuries:

Almost half (48.9%) of athletes reported they were "informed about growth plate injuries to the finger." 52.8% of these informed athletes correctly identified the injuries as stress fractures from a list of possibilities that included kind of pulley injury, dislocation, ligament injury, stress fracture, or tendon injury (*Table 2)*. However; out of all athletes (self-reported informed or uninformed), only 14.5% identified growth plate injuries exclusively as a stress fracture and only 24.5% of those who claimed to be informed answered this question correctly (*Table 2*).

Table 2. *Percent and 95% CI of athlete responses for all athletes, growth plate injury (GPI) uninformed, and growth plate injury (GPI) informed.*

		All Athletes		**GPI Uninformed**		**GPI Informed**	
		Percent	95% CI	Percent	95% CI	Percent	95% CI
Fig. 1	A2 pulley most common	35.5%	(29.1, 42.2)	41.3%	(31.8, 51.4)	30.2%	(22.0, 39.4)
Fig. 1	GPI most common	15.0%	(10.6, 20.4)	6.7%	(2.7, 13.4)	22.4%	(.152, .311)
Fig. 2	Identified GPI as a stress fracture	31.3%	(25.3, 37.7)	12.4%	(7.1, 19.6)	52.8%	(42.9, 62.6)
Fig. 2	Identified GPI ***exclusively*** as a stress fracture	14.5%	(10.2, 19.8)	5.8%	(2.4, 11.6)	24.5%	(16.7, 33.8)
Fig. 3	Correctly identified safe double dyno age	5.7%	(3.2, 9.4)	4.0%	(.56, 7.44)	7.5%	(2.8, 12.2)

Out of all the athletes in our study, 73.5% reported growth plate finger injuries to either be a type of A2 pulley injury or did not know (*Figure 2a*). The self-reported GPI informed (*Figure 2b)* appear generally more informed about growth plate

injuries to the finger as compared to the self-reported GPI uninformed (*Figure 2c).* We also found that out of 39 athletes who reported they obtained an A2 pulley injury, 82% were uninformed about growth plate injuries. Out of the self-reported GPI uninformed, 66% were involved in two or more risk factors for growth plate injuries.

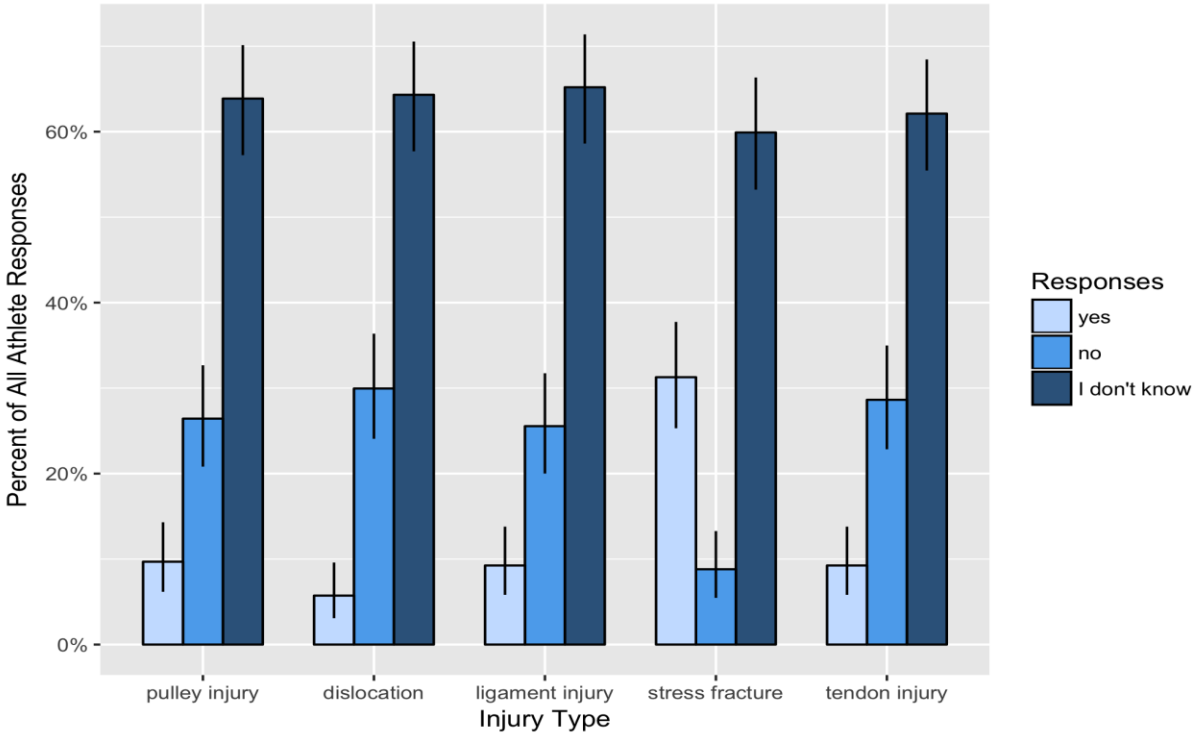

Figure 2a. *Percent of all athlete responses for the question "growth plate injuries to the finger are a…" (error bars = 95% CI, p<0.0001).*

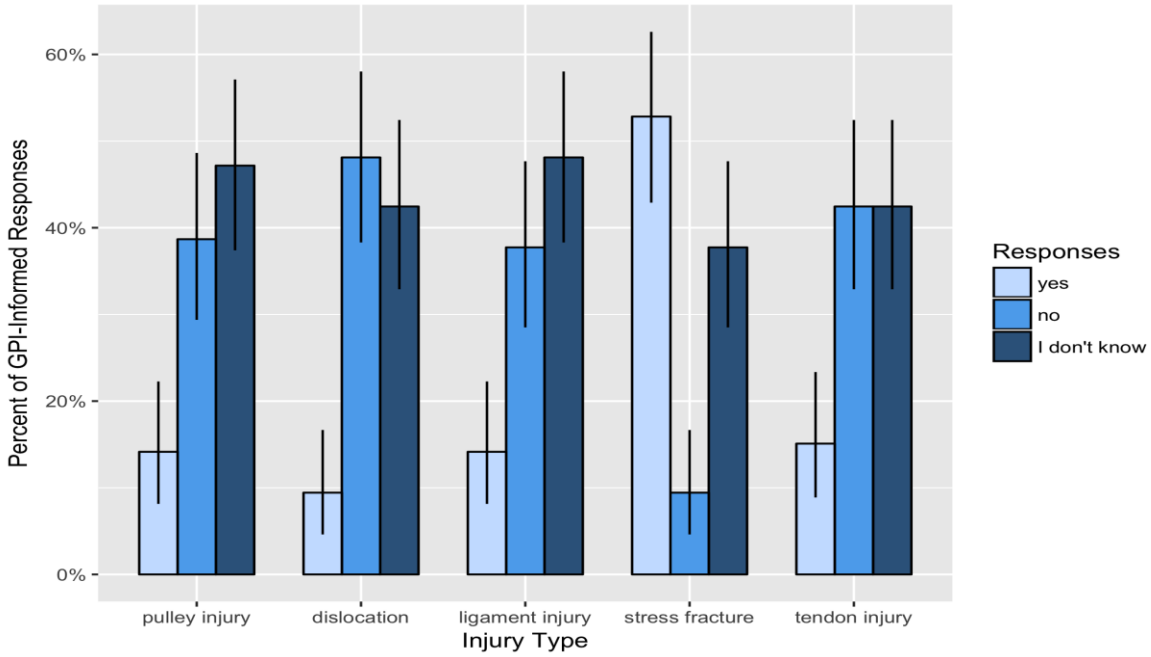

Figure 2b. *Percent of self-reported GPI informed responses for the question "growth plate injuries to the finger are a…" (error bars = 95% CI, p<0.0001).*

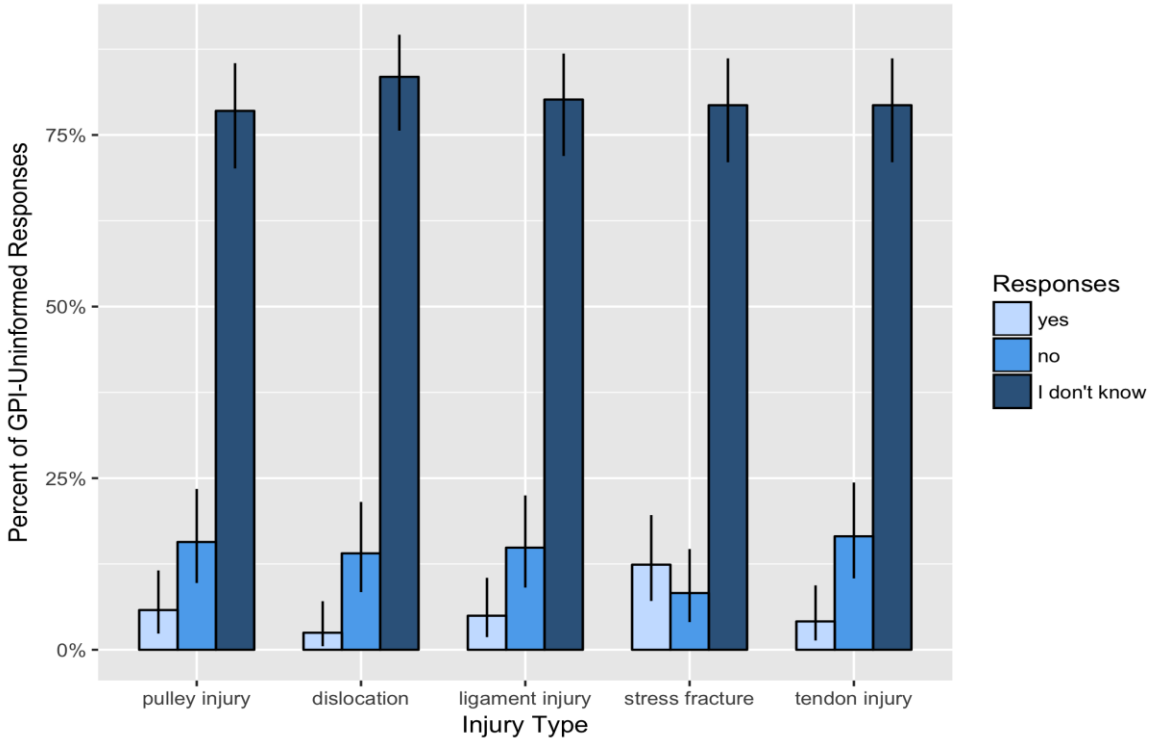

Figure 2c. *Percent of self-reported GPI uninformed responses for the question "growth plate injuries to the finger are a…" (error bars = 95% CI, p<0.0001).*

Risk Factors

Only 5.7% of athletes correctly reported the safe age (18+) to start double dyno campus board training (*Table 2*). The remaining 94.3% of athletes erroneously believed the safe age to start double dyno campus board training is less than eighteen, claimed age did not matter, or had no idea (*Figure 3a).* The percentage of athletes correctly reporting the safe age to start double dyno campus board training was not significantly different between the self-reported GPI informed, 7.5% and GPI uninformed, 4% (p=.2381) (*Figure 3b*). Lastly, out of 76.2% of athletes who trained on the campus board, only 3.45% reported they had obtained a growth plate injury.

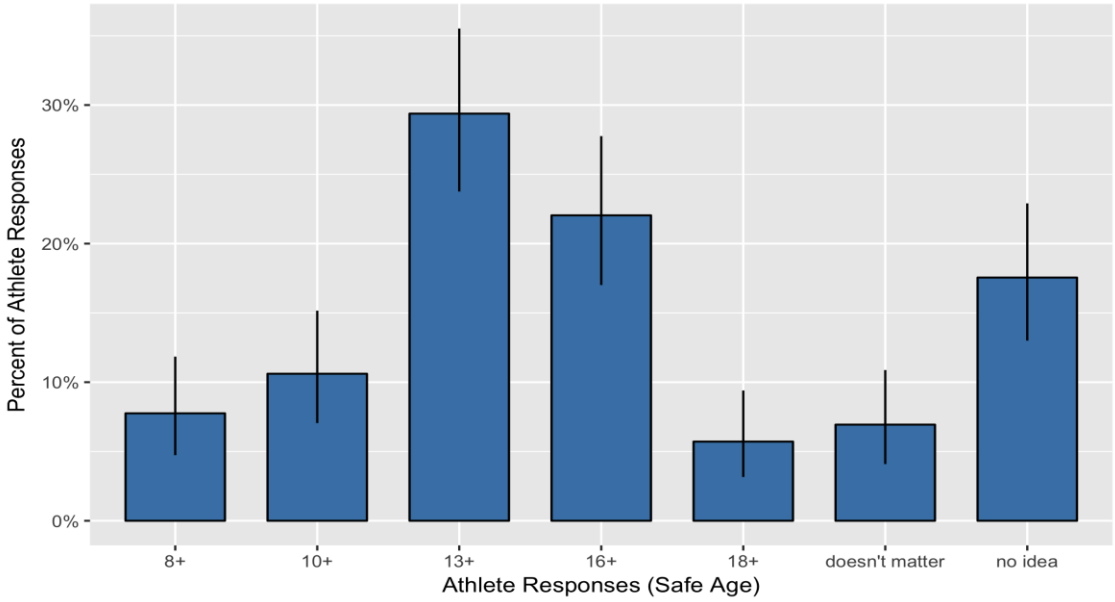

Figure 3a. *Response percentages for the question "safe age to start double dyno campusing" (error bars = 95% CI, p<0.0001).*

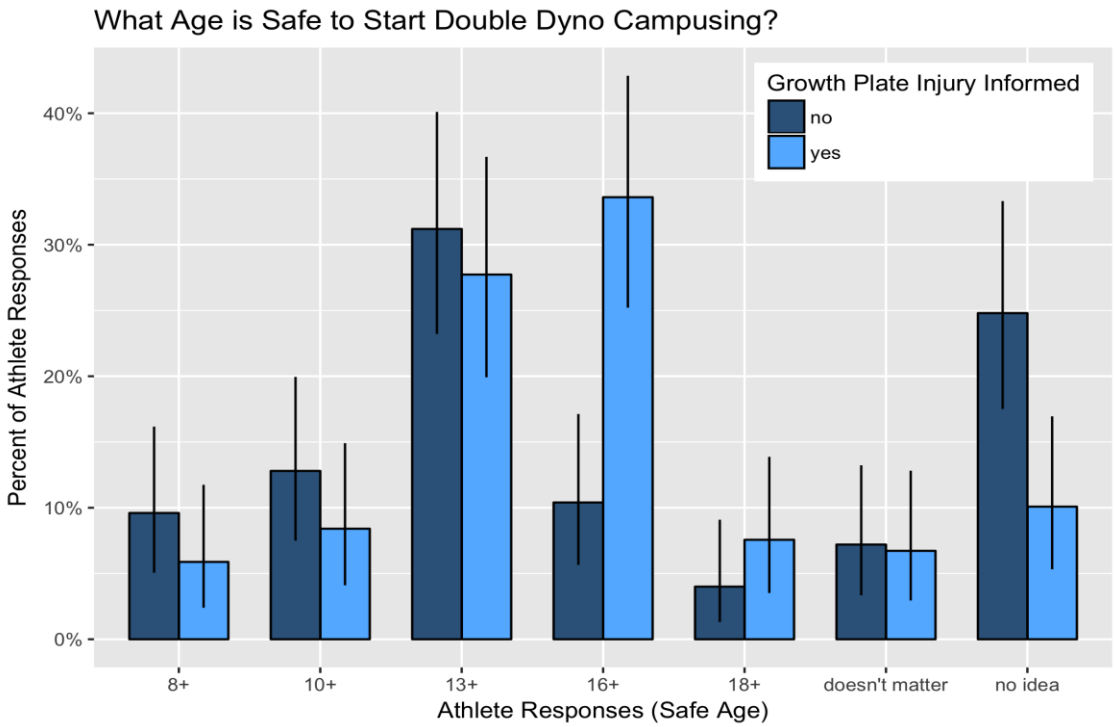

Figure 3b. *Response percentages for the question "safe age to start double dyno campusing" between GPI informed and GPI uninformed (error bars = 95% CI, p=.2381).*

Seventy-five percent of the athletes who reported they had obtained a growth plate injury to the finger were involved in two or more known risk factors as compared to 51% of the athletes who did not report obtaining a growth plate injury to the finger (*Table 3*). This finding was not statistically significant (Chi-Square, p=0.09991). We also found that athletes who trained regularly on the IFSC speed wall were significantly more likely to self-report obtaining a GPI (Fisher's Exact test, p=0.02). The risk ratio for self-reported GPI among athletes that train on the IFSC speed wall compared to those that did not is 4.32 (95% CI, 1.34, 13.94). Risk factors for GPIs were classified if the athlete trained on the campus board, trained with additional weights, or trained regularly on the IFSC speed wall.

Table 3. *Percentage of self-reported GPI informed and uninformed who are involved in 0-1 or 2-3 risk factors for growth plate injuries. Risk factors are identified as training on campus board, training with additional weights, and training regularly on the International Federation of Sport Climbing (IFSC) speed wall. Chi-square = 2.707, p= 0.09991.*

Risk Factors	Self-Reported GPI (n=12)	Self-Reported No-GPI (n=229)
0 or 1	25%	49%
2 or 3	75%	51%

Discussion:

Our data suggest widespread misperceptions exist about growth plate and A2 pulley injuries in elite, adolescent rock climbers. All injury data in our study were self-reported and very likely involved faulty self-diagnoses that stem from these misperceptions. We found that ankle sprain was reported in 16.1% of athletes, pulley injuries were reported in 14.9% of athletes, and growth plate injury to the finger was reported in only 4.6% of athletes. This finding was not in agreement with Bayer et al. (2013), Hochholzer et al. (2005), and Morrison et al. (2007) as they found growth plate injuries to the finger to be the most common injury in youth climbers. Although pulley injuries are rare in skeletally immature climbers (Schlegel et al., 2002), we expected more athletes to report obtaining an A2 pulley injury than a growth plate injury, due to widespread misperceptions about these injuries. A2 pulley injuries have been researched in the literature almost ten years prior to when epiphyseal fractures were first reported in 1997 (Schoffl et al., 2004) and are commonly talked about within the skeletally mature climber. We propose that the majority of our youth athletes falsely attributed finger pain to a pulley injury when a growth plate injury actually exists.

Further supporting faulty self-diagnoses, we found that 82% of athletes who self-reported they had a pulley injury were uninformed about growth plate injuries to the finger. Additionally, previous work by Rohrbough et al. (2000) suggest that our climbers were far too young for an A2 pulley injury. Skeletally mature climbers suffering from A2 pulley pain have a mean age of 30.7 years, while those without A2 pulley pain are significantly younger at 22.6 years ($p=0.004$). The mean age for self-reported pulley injuries in our study, 14.95±2.55 SD, was highly comparable to the mean age for self-reported growth plate injuries, 15.42±2.31 SD. Both of which were approximately 15 years younger than the mean age for skeletally mature climbers to experience A2 pulley pain. Additional research indicates A2 pulley injuries are rare in youth (Schlegel et al., 2002). In light of these points, we suspect that the youth athletes in our study are either mistaken about their A2 pulley injury, or are fabricating the injury all together. Of the athletes who were uninformed about growth plate injuries, 66% were involved in two or more risk factors for growth plate injuries and 47% were between the ages of 13-16, when growth plate injuries are extremely likely (Bayer et al., 2013; Hochholzer et al., 2005; Morrison et al., 2007). These findings further show the need for education about growth plate injuries in elite, adolescent climbers.

Our study demonstrated clear misperceptions about safe training practices for skeletally immature athletes. Not only was the A2 pulley injury erroneously reported as the most common youth climbing injury ($p<0.0001$), but the majority of athletes were also misinformed about the safe age to start double dyno campus board training. Only 5.7% of climbers correctly reported the safe age to start double

dyno campus board training, and out of those who reported they were aware of growth plate injuries, only 7.5% answered with the correct age of eighteen and older. The majority of athletes reported that the safe age to start double dyno campus board training is thirteen and older, which is ironically the most vulnerable time for a growth plate injury. Our findings do not directly suggest campus board training is a risk factor for epiphyseal fractures though, as reported by Morrison et al. (2007). This apparent discrepancy may stem from a weakness in our study. Even though training on the campus board alone is an established risk factor for growth plate injuries (Morrison et al., 2007), the addition of double dyno movements on the campus board is likely to place youth athletes at an even higher risk for growth plate injuries. In our survey, we asked if athletes trained on the campus board, without specifying if athletes train "double dyno" movements on the campus board. Schoffl et al. (2003) reported that most youth climber finger injuries occur while training and not while climbing. Increased awareness of the injury risk associated with double dyno campus board moves could help reduce the incidence of growth plate injuries in youth climbers.

Our study provides indirect evidence that growth plate injuries are prevalent and unreported in elite youth climbers. Out of 76.2% of athletes who trained on the campus board, only 3.45% reported they had obtained a growth plate injury. Previous literature shows that close to two-thirds of adolescent climbers who train on the campus board develop an epiphyseal fracture (Morrison et al., 2007). The implication is that almost half of the athletes in our study that train on the campus board may have an unreported epiphyseal fracture. Consistent with implications of

our study, Morrison et al. (2007) reported that finger injuries in elite youth climbers are likely to go unreported, especially among those who climb grades identical to elite, skeletally mature climbers. Educating adolescent climbers about the prevalence of GPIs and the scarcity of A2 pulley injuries in youth climbers may at the very least lead athletes to a proper diagnosis and care and reduce long-term damage and loss of function.

Due to dynamic movements that are similar to double dyno campus board training, we suspected training regularly on the IFSC speed wall would be a risk factor for growth plate injuries in adolescent climbers. The athletes in our study who trained regularly on the IFSC speed wall had a 1.34 to 13.94 fold higher risk of self-reporting a growth plate injury compared to athletes who did not train regularly on the IFSC speed wall. To the best of our knowledge, this is the first study to suggest training regularly on the IFSC speed wall is a risk factor for growth plate injuries. This risk factor should be studied further and use radiographic images to corroborate or invalidate our findings.

Our results suggest that the new combined scoring system format for the 2020 Olympic Games may lead to an increased frequency of growth plate injuries. Not only will every Olympic competitor have to compete in each of the three disciplines, but they will have to compete on the official IFSC speed wall. As such, a higher number of youth competitors are likely to dedicate large amounts of training time on this wall prior to the Olympic Games to prepare for the new Olympic format. In addition, not every United States climbing gym has this official speed wall, so athletes may travel to train on this wall. Without a solid training base on the speed

wall, athletes may be at an increased risk for injury. Alternatively, a healthy speed wall training-base in adolescents may not be possible. As with double dyno campus board training, training regularly on the IFSC speed wall may not be advised for the skeletally immature athlete until eighteen, or at least until the physis has fused.

As our study suggests, if speed climbing is more of a risk factor for GPIs than the existing known risk factors, we anticipate the number of GPIs to increase dramatically prior to the 2020 Olympics. Once athletes turn fourteen, they are eligible to compete in international youth speed competitions on the official IFSC speed wall. Fourteen, or around pubescent age, is the most vulnerable time for growth plate injuries (Morrison et al., 2007). The combination of the 2020 Olympic combined format and IFSC international youth speed competition rules create large incentives for athletes to train in ways that appear unsafe for skeletally immature climbers.

A limitation of our study is that all of our findings are from self-reported data and lacked validation by medical professionals or radiographic findings. Consequently, our self-reported injury data is likely affected by erroneous self-diagnoses and possibly erroneous diagnoses from medical professionals unfamiliar with youth-specific climbing. However, self-reported data supported the main purpose of our study, which was to identify perceptions of injuries and safe training practices in the skeletally immature climber. Future studies are needed though, in particular to explore the correlation suggested by our study between training regularly on the IFSC speed wall and GPIs. Using medical records and radiographic images could establish a more convincing relationship between training regularly

on the IFSC speed wall and GPIs, while also clarifying the extent of injury rates in youth climbers.

Finally, our intent is not to discourage young athletes from participating in climbing. Climbing is a wonderful sport for young athletes with many physical and mental benefits that largely outweigh the risks for injury. We hope that this study will help bring awareness, so athletes, coaches, and parents understand how to reduce the risk for growth plate injuries and long-term damage. Increased knowledge about the risk associated with 1) double dyno campus board training 2) the use of additional weights and 3) training regularly on the IFSC speed wall are likely to reduce the incidence of growth plate injuries and hopefully set young athletes up for many years of healthy climbing.

Conclusion:

Adolescent climbers are prone to characterizing skeletally immature climbing-specific injuries as A2 pulley injuries seen in skeletally mature climbers. In addition, adolescent climbers erroneously reported the safe age to start double dyno campus board training. Lastly, training regularly on the IFSC speed wall appears to be an additional risk factor for growth plate injuries. As climbing enters the 2020 Olympics, addressing misperceptions will help athletes, parents, and coaches understand the risk for growth plate injuries and guide adolescent climbers and parents to seek medical attention when appropriate. Educating youth, coaches, and parents about finger injuries may reduce the incidence of growth plate injuries and the potential for permanent finger deformity and loss of function.

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