ACTIVE & SAFE

Evidence Summary: Wrestling

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BC INJURY research and prevention unit

The British Columbia Injury Research and Prevention Unit (BCIRPU) was established by the Ministry of Health and the Minister's Injury Prevention Advisory Committee in August 1997. BCIRPU is housed within the Evidence to Innovation research theme at BC Children's Hospital (BCCH) and supported by the Provincial Health Services Authority (PHSA) and the University of British Columbia (UBC). BCIRPU's vision is *to be a leader in the production and transfer of injury prevention knowledge and the integration of evidence-based injury prevention practices into the daily lives of those at risk, those who care for them, and those with a mandate for public health and safety in British Columbia.*

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UBC BC Children's Hospital Research Institute

Evidence synthesis tool

SPORT:	Wrestling	**Target Group:**	High School, Males only	
Injury Mechanisms:	Contact with playing surface or contact with another player are most common.			
Incidence/Prevalence	**Risk/Protective Factors**	**Interventions**	**Implementation/Evaluation**	**Resources**
Overall Injury Rate 23.3/10,000 AEs (Yard et al., 2008a). **Common Injury Locations** Shoulder most commonly injured body part (injury rates 4.06 to 4.34/10,000 AEs) (Bonza et al., 2009; Robinson et al., 2014), followed by the elbow (11.3%-14.2% of all injuries) (Darrow et al., 2009; Kerr et al., 2011a; Kerr et al., 2011b) and knee (13.5%-34.4% of all injuries) (Darrow et al., 2009; Kerr et al., 2011a; Kerr et al., 2011b). **Common Injury Types** Sprains/strains most common injury type: accounted for 17.8% to 50.1% of all injury types. Other injury types include: fractures (11.1%-40.6% of all injuries) (Darrow et al., 2009; Kerr et al., 2011a; & Rechel et al., 2011) and	**Match vs. Practice** Overall injury rates significantly higher in competitions compared to practices. Injury rate ratios ranged from 1.70 to 5.09 (Bonza et al., 2009; Darrow et al., 2009; Dizdarevic et al., 2016; Kerr et al., 2011a; Kerr et al., 2011b; Mitchell et al., 2015; Rechel et al., 2011; Rechel et al., 2008; and Swenson et al., 2012). **Age (High School vs. Collegiate)** High school wrestling injuries more frequently resulted from escape and near fall compared to those sustained in collegiate wrestlers (4.7%, IPR=2.00, 95% CI 1.15-3.47 for escape and 4.0%, IPR=3.59, 95% CI 1.37-9.37 for near fall) (Yard et al., 2008a).	No evidence of interventions, but grey literature on strength and conditioning techniques (not specific to a certain population) written by clinicians and strength & conditioning specialists suggest the following injury prevention strategies: Practice safe weight training techniques with progressions (Fox, 2009). Incorporate plyometric and balance training in addition to strength training (Grindstaff, 2006). Training power and endurance will help decrease neuromuscular fatigue, with the intent to prevent injury (Grindstaff, 2006). Train in a similar environment to a wrestling match, ex: balance exercises on the mat or other unstable surface (Grandstaff, 2006). Strengthening exercises include those of the shoulder (and flexibility), neck, knees, and ankles	No implementation or evaluation studies were found in this literature review	**Websites** Stop Sport Injuries: http://www.stopsportsinjuries.org/STOP/About/STOP_Sports_Injuries.aspx

dislocations/separations (7.7% to 25.8% of all injuries) (Bonza et al., 2009; Darrow et al., 2009; Kerr et al., 2011a; Rechel et al., 2011; & Yard et al., 2008a). **Mechanisms of Injury** 25.9% to 55.4% of all injuries resulted from contact with the playing surface, while 29.2% to 59.5% of all injuries ranged from contact with another player (Bonza et al., 2009; Dizdarevic et al., 2016; Huffman et al., 2008; Kerr et al., 2011b; Mitchell et al., 2015; Rechel et al., 2011; and Swenson et al., 2012).		(Fox, 2007; Grindstaff, 2006; Lee et al., 2016). Ensure safe practice conditioning and properly fitted equipment (Hewett et al., 2005) Ensure adequate preparation before the season (Hewett et al., 2005) Referees should not condone dangerous behaviour in matches (Boden & Prior, 2005; Hewett et al., 2005). **Economic Burden of Injury** Economic evaluation: significant injury costs. Mean medical cost per injury=$670 (95% CI $573-784) (Knowles et al., 2007).		
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Lee, K., et al. (2016). The Effectiveness of cervical strengthening on decreasing neck injury risk in wrestling. *Journal of Sport Rehabilitation,* 1-17.

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Review of Sport Injury Burden, Risk Factors and Prevention

Wrestling

Incidence and Prevalence

High School

The largest number of studies on the incidence and prevalence of wrestling injuries are in male high school wrestlers from the United States. Athletic Trainers working in high schools who were affiliated with the National Athletic Trainer's Association recorded all injuries sustained by athletes participating in any of nine sports in a national database. Authors reported injury data captured between the 2005-2006 and 2014-2014 seasons that were recorded in this national database. All were prospective cohort studies. In each study (unless otherwise specified), an injury is defined as any complaint requiring medical attention from the certified athletic therapist or a physician that resulted in at least of day of restriction from participation in a wrestling practice or competition. Rates are reported per athlete–exposure, defined as participation in one practice or competition. One study reported on the rate of overall injuries over one academic year (2005-2006); with 23.3/10,000 athlete-exposures (Yard et al., 2008a).

The shoulder is consistently the most commonly injured body part in high school wrestlers, with injury rates reported between 4.06 to 4.34 per 10,000 athlete-exposures (Bonza et al., 2009 & Robinson et al., 2014), accounting for 16.6% of all injuries requiring surgery (Rechel et al. 2011), 21.7% of injuries resulting from player-to-player contact (Kerr et al. 2011a), 24% of all severe injuries resulting in greater than 3 weeks of participation time-loss (Darrow et al., 2009), and 54% of all dislocations/separations (Kerr et al., 2011b). The knee and elbow are also two commonly injured body parts, ranging from 13.5% to 34.4% of all injuries for the knee (Darrow et al., 2009; Kerr et al. 2011a; Kerr et al., 2011b; & Rechel et al. 2011) and 11.3% to 14.2% for the elbow (Darrow et al., 2009; Kerr et al. 2011a; & Kerr et al., 2011b). Although the shoulder is consistently the most common injury in wrestlers, Huffman et al. (2008) reported that the rate of lower extremity injuries overall was 7.5 per 10,000 athlete-exposures.

The most common type of wrestling injury is sprains/strains, accounting for 17.8% to 50.1% of all injury types. Other injury types include fractures, accounting for 11.1% to 40.6% of all injuries (Darrow et al., 2009; Kerr et al., 2011a; & Rechel et al., 2011) and dislocations/separations, accounting for 7.7% to 25.8% of all injuries (Bonza et al., 2009; Darrow et al., 2009; Kerr et al., 2011a; Rechel et al., 2011; & Yard et al., 2008a). Sprains/strains account for 50.1% of all shoulder injuries and dislocations/separations account of 25.8% of these injuries (Bonza et al., 2009). Although not commonly reported as a common injury type, concussions account for approximately 5-10% of all injuries (Kerr et al., 2011; Tirabassi et al., 2016; & Yard et al., 2008a), and, along with knee sprains, are the more common reason for medical disqualification (Tirabassi et al., 2016). Rosenthal et al.

(2014) found that concussion rates in wrestling have increased from the 2005-2006 season (1.7/10,000 athlete-exposures, 95% CI 1.2-2.5) to the 2011-2012 season (5.7/10,000 athlete-exposures, 95% CI 4.6-4.0). Incidence rate of injuries that are season-ending due to the severity are reported at 1.73 injuries per 10,000 athlete-exposures, and 0.06 per 10,000 athlete-exposures are career-ending (Tirabassi et al., 2016).

Almost all injuries reported in the high school studies resulted from contact with the playing surface (ranging from 25.9% to 55.4% of all injuries) (Bonza et al., 2009; Dizdarevic et al., 2016; Huffman et al., 2008; Kerr et al., 2011b; Mitchell et al., 2015; Rechel et al., 2011; and Swenson et al., 2012), or contact with another player (ranging from 29.2% to 59.5%) (Bonza et al., 2009; Dizdarevic et al., 2016; Huffman et al., 2008; Kerr et al., 2011b; Mitchell et al., 2015; and Rechel et al., 2011). The most common mechanism of injury resulting from contact with another player occurred during the takedown for elbow dislocations (Bonza et al., 2009), rare injuries (Huffman et al., 2008), injuries that required surgery (Rechel et al., 2011), injuries that resulted in medical disqualification (Tirabassi et al., 2016), and overall injuries (Yard et al., 2008). Sparring was also a common mechanisms of injury during contact with another player (Bonza et al., 2009; Rechel et al., 2011; and Yard et al., 2008).

A prospective cohort study performed an economic evaluation on injuries from high school sports using a sample of 100 public high schools in North Carolina. The medical costs associated with wrestling injuries were significant. The mean medical cost per injury was $670 (95% CI $573-784), mean human capital cost per injury was $2,080 (95% CI $1,782-2,428), and the mean comprehensive cost per injury was $10,212 (95% CI %8,607-12,115) (Knowles et al., 2007).

None of the studies included females, since female wrestling was not part of the varsity program in many of the eligible schools.

Collegiate

All studies examining wrestling injuries in the collegiate population include National Collegiate Athletic Association (NCAA) athletes. Overall injury rates are commonly reported (Agel et al., 2007; Agel & Schisel, 2013; Kerr et al., 2015; & Yard et al., 2008a). One study focuses on concussion data (Kerr et al., 2016) and one reports specifically on acromioclavicular joint sprains (Hibberd et al., 2016).

Both studies reporting overall injury rates in collegiate wrestlers are prospective cohorts, though Kerr et al. (2015) collected data from wrestlers over six seasons (2009 to 2014) while Yard et al. (2008a) collected data from a single season (2005-2006). Among the thirteen collegiate sports included in their study, Kerr et al. (2015) found that wrestling had the highest injury rate, at 13.1 injuries per 1,000 athlete-exposures (95% CI 12.3-13.9). When comparing this study to Yard et al. (2008a), the injury incidence rate reported in the 2005-2006 season was lower at 7.25 per 1,000 athlete-exposures (Yard et al., 2008a).

When comparing overall injuries between seasons, Agel & Schisel (2013) reported the highest injury rates during pre-season, at 8.3 injuries per 1,000 athlete-exposures (95% CI 8.0-8.5). This was significantly higher when compared to in-season (4.7 injuries per 1,000 athlete-exposures, 95% CI 7.4-4.9) and post-season (1.8 injuries per 1,000 athlete-exposures, 95% CI 1.5-2.1).

Although only two studies compared injury locations, both reported the knee as the most commonly injured body part, comprising 24.8% of all injuries (Yard et al., 2008) and an injury rate of 6.03 per 1,000 athlete-exposures (95% CI, 5.58-6.47) in matches and 0.84 injuries per 1,000 athlete-exposures in practices (95% CI 0.79-0.89). Both studies also reported shoulder strains/sprains as a common injury; comprising 8.1% of all injuries (Yard et al., 2008), and a rate of 1.45 injuries per 1,000 athlete-exposures in matches and 0.21 injures per 1,000 athlete-exposures in practices (Agel et al., 2007). Per 1,000 athlete-exposures, injury rates for ankle sprains were 1.97 (95% CI, 1.72-2.22) in matches and 0.41 (95% CI, 0.38-0.45) in practices. Concussions were also common, reported at a rate of 1.27 concussions (95% CI, 1.07-1.48) in matches and 0.14 (95% CI 0.12-0.17) in practices (Agel et al., 2007), and 0.89 per 1,000 athlete-exposures overall (Kerr et al., 2016). Other common specific injury types and locations reported by Yard et al. (2008a) included head and face lacerations (7.4%), ankle strains/spains (7.0%), concussions (5.8%), trunk strains/sprains (5.0%), and upper leg/hip strains/sprains (5.0%). A recent study that specifically examined acromioclavicular joint sprains found that this type of injury rate was high, at 15.3 injuries per 1,000 athlete-exposures (Hibberd et al., 2016).

Almost half of all wrestling injuries reported by Yard et al. (2008a) were not severe, with the athlete returning to sport within one week of sustaining the injury. Thirty percent of athletes were unable to resume wrestling until one to three weeks post-injury, while 27.1% sustained an injury that was severe enough for them to miss more than three weeks of wrestling participation. One-quarter (24.3%) of these severe injuries were due to knee strains/sprains, 15.5% were due to shoulder dislocations/subluxations, 8.6% from knee cartilage injuries, and 7.1% from shoulder sprains and strains. Surgery was required for 7.9% of all injuries, 25% of which resulted from knee strains/sprains, 20% from knee cartilage tears, and 15% from shoulder dislocation/subluxations.

Although there were not as many studies examining wrestling injuries at the collegiate level compared to those in high school, the included studies are of good quality, utilizing athletic therapists to record the injury data. The results consistently demonstrate the high incidence of knee, shoulder, ankle, and concussion injuries in wrestling, with strains/sprains and dislocations/subluxations accounting for many of the severe injuries.

Military Academy

Three prospective cohort studies examine injury rates in males attending the United States Military Academy (Pallis et al., 2012; Roach et al., 2014; & Yard et al., 2008).

Wrestling was reported to have the highest injury rate of all intercollegiate sports (Roach et al., 2014). The overall injury rate during a national tournament including cadet and juniors was 5.8 injuries per 1,000 athlete-matches. This included 7.0 injuries per 1,000 athlete-matches for freestyle wrestlers, and 4.6 injuries per 1,000 athlete-matches for Greco-Roman wrestlers. Just under half (44.1%) of all injuries resulted in a defaulted match, and wrestlers were unable to continue in the tournament, while 40.9% completed the match and continue in the tournament (Yard et al., 2008b).

The most commonly injured body parts for overall injuries in both Greco-Roman and freestyle wrestlers were the head/neck face (36%), followed by the shoulder/clavicle (17.6%), and knee (16.2%). Sprains/strains are the most common type of injury (40.7%), concussions (17.0%), and fractures (11.1%) (Yard et al., 2008b). The remaining two studies focused on specific injury types at both the intercollegiate and intramural levels. Medial collateral ligament (MCL) injury rates over four years were 0.57 per 1,000 athletic-exposures at the collegiate level, and 0.21 per 1,000 athletic-exposures at the intramural level (Roach et al., 2014). The rate of acromioclavicular joint injuries was 0.43 per 1,000 athletic-exposures at the intercollegiate level, and 0.11 per 1,000 athlete-exposures at the intramural level (Pallis et al., 2012).

Youth

Two studies have been conducted in youth populations (Beachy et al., 2014 & Myers et al., 2010). A 20-year prospective cohort study in wrestling injuries sustained by middle school athletes was the only study to include female wrestlers. Overall injury rates were not reported, but comparisons were reported between males (n=625) and females (n=39). Per 1,000 athlete-exposures, female wrestlers experienced 10.26 injuries and males experienced 9.95 injuries. Over the 20-year period, the sample size for females is small, and results should be interpreted with caution (Beachy et al., 2014).

Myers et al. (2010) conducted a cross-sectional study to determine wrestling injury characteristics using hospital injury data reported to the National Electronic Injury Surveillance System. Only males (aged 7-17 years) were included in this study. The authors reported injury rates by age group; young (7 to 11 years) and old (12-17 years).
Myers et al. (2010) found that the annual rate of injury in older youth male wrestlers (aged 12-17 years) was 5 times the injury rate of younger wrestlers (29.57 injuries/1,000 wrestlers/year, 95% CI 26.74-32.40 in older group vs 6.49 injuries/1,000 wrestlers/year, 95% CI 4.97-8.03 in younger group). In contrast, the mechanism of injury was similar between the age groups. For both younger and older groups, the precipitating mechanism of injury included overexertion (32.9%, 95% CI 26.9-38.9 vs 35.0, 95% CI 33.2-36.9), struck by/against (31.5%, 95% CI 25.5-37.5 vs 34.0%, 95% CI 32.1-35.8), and fall/takedown (22.7%, 95% CI 17.4-28.1 vs 17.1%, 95% CI 15.7-18.6). This was consistent with injuries by direct mechanism, which included struck by/against (46.5%, 95% CI 40.1-52.9 vs 44.5%, 95% CI

42.5-46.4), overexertion (33.0%, 95% CI 27.0-39.0 vs 35.5%, 95% CI 33.7-37.4), and fall/takedown (7.1%, 95% CI 3.9-10.4 vs 6.3%, 95% CI 5.4-7.2).

The most common injury types in both age groups included sprains/strains (38.7%, 95% CI 32.4-44.9% in younger wrestlers and 36.6%, 95% CI 34.7-38.5% in older wrestlers), fractures (25.9%, 95% CI 20.3-31.5% in younger wrestlers and 22.0%, 95% CI 20.5-23.7% in older wrestlers), and contusions/abrasions (16.3%, 95% CI 11.5-21.2% in younger wrestlers and 15.0%, 95% CI 13.6-16.4% in older wrestlers). Approximately 75% of all injuries occurred above the waist. The wrist/hand/finger was the most commonly injured body part in both younger (18.6%, 95% CI 13.6-23.6%) and older wrestlers (18.5%, 95% CI 6.9-20.0%). This was followed by the head/neck (15.8%, 95% CI 11.2-30.4%) and shoulder (11.9%, 95% CI 7.7-16.1%) in younger wrestlers, and by the shoulder (15.0%, 95% CI 13.6-16.4%) and head/neck in older wrestlers (14.5%, 95% CI 13.2-15.9%).

Other

Only one study included elite wrestlers in an international tournament. Junge et al. (2009) recorded injuries requiring medical attention during the Beijing Summer Olympic Games across all sports. A total of 9.4% of all wrestlers sustained an injury during the Games.

Summary

Wrestling is a sport that results in high injury rates, particularly in the high school and collegiate levels, and is reported as the sport with the highest injury rates when compared to other sports (Kerr et al., 2015). Research examining injuries in male high school and collegiate wrestlers is recent, well-supported, and includes strong evidence on the locations and types of injuries. Results are consistent across studies, and data has been collected prospectively from Certified Athletic Trainers using large sample sizes. The economic evaluation further supports the burden of injuries. There is a need for similar research in the Canadian population.

Shoulders and knees are the most commonly injured body parts across studies, with sprains/strains and dislocations as the most common types of injuries. This is expected, due to the large rotational torque forces that are involved in many wrestling movements (Roach et al., 2014).

A major limitation in the research is that females are not included in both the high school and collegiate wrestling studies. The only study to include females was in middle school wrestlers, and females comprised less than 6% of the total sample size. This is due to the lack of programming for females at both the high school and varsity levels. According to the National Wrestling Coaches Association, there are now over 11,000 high school female wrestlers in the United States, and wrestling programs now exist in at least

30 colleges (www.nwcaonline.com). Research on wrestling injuries in females is warranted in order to inform the development of appropriate interventions and prevention strategies.

All populations reporting on wrestling injuries included in this review involve American populations, with the exception of the elite study reporting injuries sustained during wrestling (among other sports) in the Beijing Olympic Games. This data is likely relatable to the Canadian population, but future studies should include Canadian athletes specifically.

Risk and Protective Factors

High School

As with incidence and prevalence studies, there are several studies reporting on risk factors in high school males for a variety of different injury types.

Match vs Practice

Injury rates are significantly higher in competitions compared to practices, with incidence rate ratios ranging from 1.70 to 5.09 (Bonza et al., 2009; Darrow et al., 2009; Dizdarevic et al., 2016; Kerr et al., 2011a; Kerr et al., 2011b; Mitchell et al., 2015; Rechel et al., 2011; Rechel et al., 2008; and Swenson et al., 2012). The overall practice injury rate was 20.4/10,000 athlete-exposures (Rechel et al., 2008). Practice injury rates, reported per 10,000 athlete-exposures, included 2.74 for shoulder injuries (Bonza et al., 2009), 3.9 for severe injuries (Darrow et al., 2009), 0.13 for elbow dislocations (Dizdarevic et al., 2016), 1.38 for all dislocations/separations (Kerr et al., 2011b), 0.21 for patellar instability (Mitchell et al., 2015), and 1.96 for fractures (Swenson et al. 2012). Injuries requiring surgery were reported at a rate of 1.14 (Rechel et al., 2011), while 1.11 were season-ending, and 0.05 were career-ending (Tirabassi et al., 2016). Overall competition injury rate was 39.3/10,000 athlete-exposures, and was higher in all instances. Per 10,000 athlete-exposures, injury incidence rates were as follows; 9.13 for shoulder injuries (Bonza et al., 2009), 39.1 for severe injuries (Darrow et al., 2009), 0.66 for elbow dislocations (Dizdarevic et al., 2016), 3.69 for all dislocations/separations (Kerr et al., 2011b), 0.74 for patellar instability (Mitchell et al., 2015), and 3.34 for fractures (Swenson et al. 2012). Injuries requiring surgery were reported at a rate of 3.06 (Rechel et al., 2011), while 3.49 were season-ending, and 0.08 were career-ending (Tirabassi et al., 2016).

Results from a study comparing the epidemiology of practice and competition injuries did not demonstrate similar magnitudes of difference. Lower extremity injuries and head/face/neck injuries were more common in practice compared to competition (31.6% vs 29.4% and 19.4% vs 17.9%; respectively), while a higher proportion of upper extremity injuries was reported during competition compared to practice (40.5% vs 31.6%), although none of these differences were statistically significant. Injury proportions were similar

between practices and competitions for all reported injury types, including strains/sprains, contusions, fractures, and concussions (Rechel et al., 2008).

Collegiate

Match vs Practice/Division

Competition and practice injury data from NCAA wrestling over a twelve year-period that included all injuries (requiring medical attention and resulted in at least one day participation time loss) reported the overall injury rates were significantly higher in competition (26.4, 95% CI 25.4-27.3) compared to practice (5.7, 95% CI 5.5-5.7) (Agel et al., 2007). This was consistent with a prospective study conducted over the 2005-2006 academic year, where the rate of injury in a match was 5.07 times the rate of injury in a practice (95% CI, 3.96-6.50) (Yard et al., 2008a). Practice injury rates during the pre-season were almost twice as high as regular season injury rates (incidence rate ratio=1.8/1,000 athlete-exposures, 95% CI 1.7-1.9) during the twelve-year period. Injury rates were also increased with division level, where Division III=5.1 injuries/1,000 athlete-exposures (95% CI 4.9-5.4), Division II=5.3 injuries/1,000 athlete-exposures (95% CI 5.1-5.6), and Division I=6.2 injuries/1,000 athlete-exposures (95% CI 6.0, 6.4) (Agel et al., 2007).

One study on NCAA wrestlers only included acromioclavicular joint sprain injuries over six academic years, thus their sample size was very small (n=16). The majority of these injuries (87.5%) were caused by contact with the playing surface, and occurred during the takedown (56.3%). Once again, the injury rate was significantly higher during competition compared to practice (rate ratio=6.67, 95% CI 2.48-17.90) (Hibberd et al., 2016).

A study comparing injuries between high school and collegiate wrestlers during the 2005-2006 academic year reported on body part of injury, severity of injury, injuries requiring surgery, and mechanism of injury (Yard et al., 2008a). The rate of knee injury was significantly higher in collegiate compared to high school students (IPR=1.61, 95% CI 1.30-2.00), while high school wrestlers demonstrated a significantly higher proportion of elbow and hand injuries compared to collegiate wrestlers (IPR=4.34, 95% CI 1.97-9.58 and IPR=2.25, 95% CI 1.14-4.45; respectively). High school wrestling injuries more frequently resulted from escape (9.3%) and near fall (14.3%) compared to those sustained in collegiate wrestlers (4.7%, IPR=2.00, 95% CI 1.15-3.47 and 4.0%, IPR=3.59, 95% CI 1.37-9.37; respectively). College injuries more frequently resulted from sparring (IPR=1.85, 95% CI 1.51-2.26) compared to high school. In matches, a greater proportion of injuries in collegiate wrestlers resulted in time loss compared to high school wrestlers (39.6% vs 23.3%, IPR=1.70, 95% CI 1.33-2.16).

Wrestling Style

Yard et al. (2008b) compared Greco-Roman versus freestyle injury risk factors in a US national tournament including 300 male cadet and junior wrestlers. Overall, the most common mechanisms of injury included 'Other' (33.9%), being driven into the mat (31.4%), contact with an opponent (22.9%), and non-contact (11.0%). The injury proportion ratio demonstrated that the proportion of injuries occurring in Greco-Roman wrestling was significantly higher compared to freestyle (IPR=2.97, 95% CI 1.72-5.14). For head, face, and neck injuries, those in freestyle wrestling most often resulted from contact with an opponent (78.3%), while those in Greco-Roman wrestling resulted from being driven into the mat (57.1%). Knee injuries were also common injuries in freestyle wrestling, resulting from contact (70.6%). Shoulder and clavicle injuries in Greco-Roman style wrestling resulted from being driven into the mat (70.0%), as did concussions (90.9%).

Previous Injury, Age, Experience

Kordi et al. (2012) examined fractures and dislocations in 495 male wrestlers at a national tournament in Tehran (mean age 18.0 +/- 4.3 years), including both Greco-Roman and freestyle wrestlers. Overall, those with a history of injury had a significantly increased risk of sustaining a fracture or dislocation in the tournament compared to those without a history of injury (IRR=19.7, 95% CI 6.3-36.6). Injury incidence increased with years of wrestling experience (IRR=1.25 injury increase per year, 95% CI 1.12-1.40, p=0.01) and with age (for every 5 year increase in age, IRR=2.19, 95% CI 1.32-3.75).

Summary

Risk factor studies report that injury rates are higher in competitions compared to practices. There is no evidence comparing males and females due to the lack of female participants and evidence is also lacking in age group comparison, and years of wrestling experience. Existing risk factor studies can help inform areas to address when developing intervention strategies.

Opportunities for Prevention: Effective Interventions, Cost-effectiveness, Implementation and Evaluation

There were no studies that implemented or evaluated interventions for injury prevention in wrestlers. A few newsletters and commentaries from strength and conditioning coaches and clinicians were revealed in the grey literature, with most discussing training techniques. The following are recommendations from such personnel who work with wrestling athletes:

General

Training with a focus on safe weight training techniques using proper form is of the utmost importance. Progressions should also be incorporated into a training program (Fox, 2009). In addition to resistance training, it is important to additionally incorporate

plyometric and balance training into a wrestler's training program. It is important to incorporate this training in a wrestling-specific environment, such as working on unstable surfaces that mimic wrestling mats, and exposing the athlete to external stimuli such as perturbations (Grindstaff, 2006).

It is also important to incorporate core strength into a wrestler's training program, to ensure a balance between one's abdominal muscles and lower back muscles (Fox, 2009). Resistance training types should focus on achieving maximum power and power endurance that will allow a wrestler to be successful over the course of an entire practice session or match. Greater power and endurance will help decrease neuromuscular fatigue, which may alter joint mechanics and decrease motor control. Interval training for muscular and aerobic fitness is very applicable to wrestling (Grindstaff, 2006).

The following training strategies are specific to different areas of the body:

Shoulder

To strengthen the shoulder and prevent injuries in this joint, the athlete should incorporate flexibility exercises, develop rotator cuff strength, and work on achieving proper muscle balance. Both weight-bearing and non-weight bearing exercises should be included. Multiplanar plyometric exercises that utilize one and both upper extremities are also important (Grindstaff, 2006).

Neck

Neck strengthening exercises (both static and dynamic) should include rotation, flexion-extension, and side bending (Grindstaff, 2006 & Lee et al., 2016). This will decrease concussion risk by developing greater anticipatory muscle activation within the neck, thus reducing the magnitude of the kinematic response to a dangerous head movement. Although research in this area is lacking in wrestlers, football studies have shown that cervical stiffness is important, as increased neck stiffness and less movement resulting from a perturbation may decrease the risk of concussion (Lee et al., 2016). Some examples of exercises that strengthen the deep neck flexors include:

- Four-way neck exercise
- Shrugs
- Shoulder press
- Bridge

(Lee et al., 2016).

Knee & Ankle

Exercises to strengthen the knee and ankle joints include resistance training for the lower extremities, balance and proprioception training, and plyometrics. Changing the

support surfaces (i.e. from a floor to a wrestling mat) is extremely important for lower body training. These exercises may include:

- Balance on solid and soft surfaces, with eyes-open and eyes-closed
- Single-leg squats on the wrestling mat
- One foot hops on the wrestling mat: hopping in one spot, hopping laterally in and out of wrestling circle, and hopping around the full circle

(Fox, 2007).

It should be noted that lateral asymmetries, especially with the quadriceps muscles, is common in wrestlers. Training programs should ensure bilateral strength development to help prevent injury (Drid et al., 2009).

Based on a literature review of incidence/prevalence of wrestling injuries and the associated risk factors, Hewett et al. (2005) provided recommendations for injury prevention strategies. These include having adequate space for wrestlers during practice and on high quality mats, ensuring wrestlers are participating with headgear that is properly fitted, practicing earlier in the season and ensuring wrestlers are adequately prepared before initiating competitions within the season, using high quality mats that are replaced when worn, and implement pre-participation screening at the beginning of the wrestling season. Authors have also noted that the referee can play an important role in injury prevention by being able to anticipate dangerous moves and being in control of the match. Referees should also strictly enforce penalties for illegal and dangerous activities (Boden & Prior, 2005 & Hewett et al., 2005).

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